OHIO STATE
UNIVERSITY
MAR 30 1945
LIBRARY

Wood for a New Age

Chem

CHEMISTRY

New Age Wood 1
Fires With Safety 9
More Rubber, Less Marihuana 13
New Pocket-Size Solar Still 14
Chem Quiz: All Colors of the Rainbow 15
New Adhesives Provide Slip-Proof Walks 15
Inventors Ahoy! Navy Lists Problems 16
Gibbs Nominated to 1945 Hall of Fame 17
Chemistry in Medicine 18
Bomber Blisters Optically Perfect 25
"Patented U.S.A." 28
New Glass Resists Hydrofluoric Acid 31
Chemical Things to Do:
Home-made Laboratory Furnace 32
Chemical Remedy from Fungus 33
The Work of the Chemical Profession:
II. Tasks of Chemists and Chemical Engineers 34
Smoke May Bring on Asthma 42
Classics of Chemistry:
Primitive Methods for Noble Metals 43
Who's Who in Ancient Metallurgy ... 60
Editorial:
Post-War Materials .....
Inside Front Cover.

MARCH
1945

25¢

★ A SCIENCE SERVICE PUBLICATION ★

Post-War Materials

➤ WILL THE POST-WAR WORLD be a paradise of dustless, air-conditioned homes where human super-robots sit at continuous bridge games in a nirvana of bliss, watched over by the electric eyes of automatic machines which tenderly fulfill their every wish? Or is the path the world is following a slick roller-coaster plunging us faster every instant into a surrealist nightmare of tortuous shapes and whirring sounds where we shall be lost in a maze of astounding inventions contrived with never-before-imagined materials? In sober reality, it is not likely that either of these dubious goals will be reached immediately after V-day.

What is happening to materials is that they are being re-worked so that each property that they can be made to exhibit can be made useful for a particular purpose. Once, when man wanted to travel, he felled a tree, lopped away the branches and burned out the center of the log to make a canoe. Most of the tree was wasted. When he discovered how to saw up the tree into lumber and build a ship or a wagon there was less waste, and he learned to utilize the properties that wood has. Now he separates and re-combines those properties.

Today the chemist works up logs into cellulose, resin and lignin, if he wishes. If he does not like some of the properties of wood, he changes them. For modern travel, no longer limited by the size and shape of a tree, he selects wood's cell structure for lightness and strength, uses the stickiness of resin to build up the cells into a laminated airplane wing, and takes off.

CHEMISTRY

Vol. 18, No. 7 — Formerly The Chemistry Leaflet, Including The Science Leaflet — March 1945

Published monthly by Science Service, Inc., the institution for the popularization of science. Publication Office: 119 South Frazier St., State College, Pa. Editorial and Subscription Office: 1719 N St., N.W., Washington 6, D. C. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of March 3, 1879.

25c a Copy; $2.50 a Year. Two-Year Subscription $4; Your Own and a Gift Subscription $4. Quantity Subscriptions, 10 or more copies to same address: $1.70 a Year, $1 for seven months, November through May, 15c each Copy each Month. No charge for Foreign or Canadian Postage.

Editors: WATSON DAVIS and HELEN MILES DAVIS
Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944.)
Board of Consulting Editors in process of formation.

Copyright 1945 by Science Service, Inc. All rights reserved. Science Service issues press service for newspapers and magazines, publishes Science News Letter (weekly) and Overseas Science News Letter (monthly), issues THINGS of Science (monthly) and administers Science Clubs of America.

Science Service is the educational and scientific institution organized in 1921 as a non-profit corporation with trustees nominated by the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the E. W. Scripps Estate and the Journalistic Profession.

➤ TOMORROW'S FOREST *seeded from remaining old growth on top of knoll.*

New-Age Wood

by WATSON DAVIS

➤WOOD — the stuff from trees — has grown a long way from the log cabins of our pioneers, the quartered oak of the gay 90's, or even the smoothly planed lumber of just before Pearl Harbor.

Wood is entering new fields of usefulness as new processes enable it to perform tasks never before possible. In the post-war world sticks of timber will be shot full of strengthening plastic, sliced into thin layers and welded together, squeezed into metallic hardness, converted into lustrous resin, made into a superpaper as strong and useful as aluminum sheet, injected to resist fire and decay, or dyed internally and externally with colors of the rainbow.

From the forests can now be obtained fibers that rival the wool from the backs of sheep. Trees can now yield food and drink (alcoholic) for man, beast and industry. Fortunately we can use our lumber and have these other things too. Because wood wool comes from unused bark, and floods of chemicals may come from sawdust and shavings.

Chemists predict that the usefulness

CHEMISTRY HALL LIBRARY

of cellulose (used for paper, rayon, explosives) may even be exceeded by another part of the wood, lignin it is called, that has been allowed to flow down our rivers as troublesome, black, gooey waste from paper-making and chemical wood processing.

The lumberman of the future will add processing plants and factories to his crews of loggers and sawmills. The scientist has cried "Timber!" and his new discoveries and inventions are crashing among us to give us new things for home and work-a-day world.

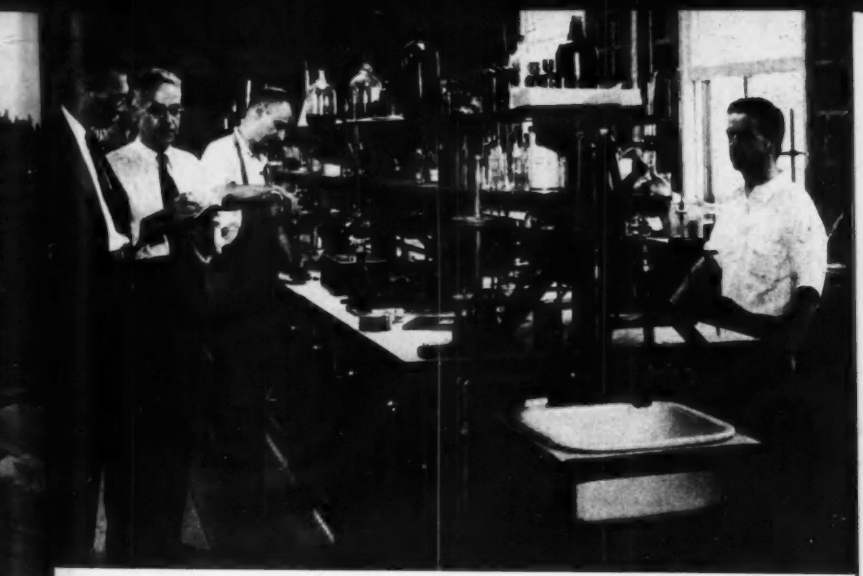
There is one new process that makes, for example, maple as hard as ebony.

The new processed wood is what nylon is to cotton. For certain finishes carpenters will ask for "urwood" or "urally" or whatever name is adopted, instead of just a piece of wood.

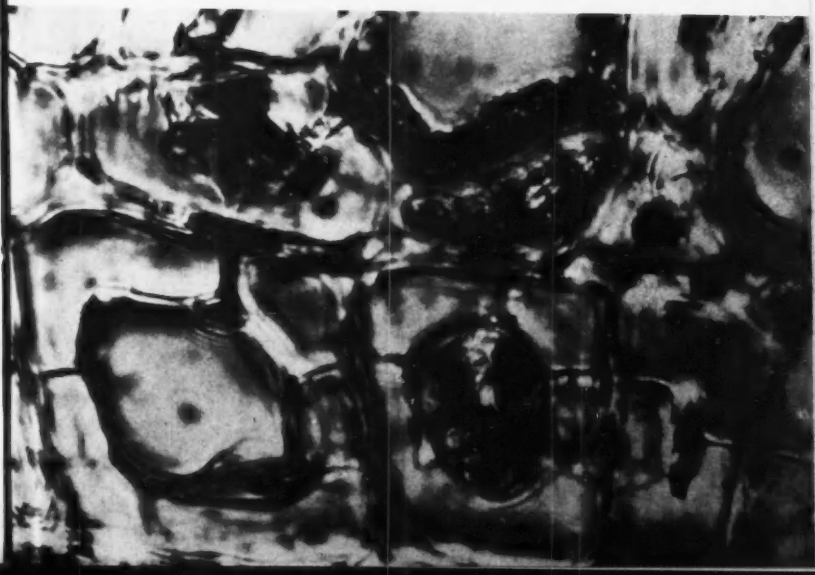
In selecting the post-war furniture, the tag may be expected to read something like: "This furniture is made from processed wood that will not swell, shrink or warp. It will give good service anywhere, even in tropic jungles or arid deserts."

Doors and bureau drawers that will never stick in muggy weather or rattle during dry spells will be a welcome result of the new transmuted wood that keeps its shape no matter what the humidity.

The trick is to combine with the natural wood one of the new kinds of



THE LUMBER INDUSTRY LABORATORY *of the Timber Engineering Company in Washington, D. C. carries on experiments on wood as an industry project. Here its chemists have been able to photograph dimethylolurea as it seeps into the cells of the wood, showing a dark color in the picture below.*



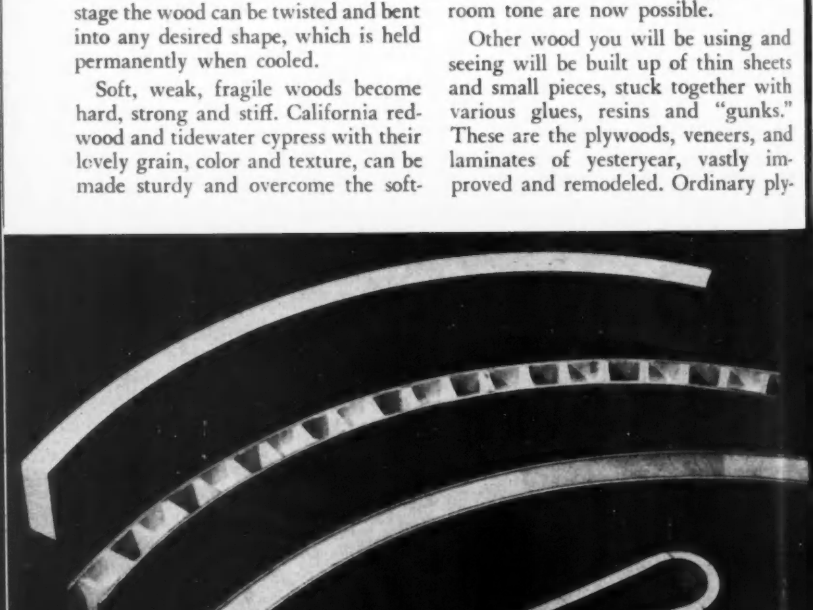
plastics, which itself can be made in part from wood, although it usually isn't. This methylolurea, which sounds complicated but really isn't since it is a white solid, soluble in water, is made from ammonia (familiar as a kitchen cleaner), carbon dioxide (which you exhale every few seconds), and methanol (the non-drinkable "wood alcohol" as it used to be called when it was made from wood as it isn't always now.)

Wood soaked under pressure in a solution of this chemical has formed within it hard and water-insoluble resins which occupy the wood cells and even the cell walls. Heated at this stage the wood can be twisted and bent into any desired shape, which is held permanently when cooled.

Soft, weak, fragile woods become hard, strong and stiff. California redwood and tidewater cypress with their lovely grain, color and texture, can be made sturdy and overcome the softness, virtues that become disabilities for some uses. Low-cost softies of the lumber world when transmuted become competitors of prized hard maple, oak and walnut in their natural state. The hard woods of our forests when urea-alloyed serve like the dense tropical timbers imported from distant lands. They become like metals.

Beautiful colors that no tree ever dreamed of can be infused permanently through the wood by mixing in dyes along with the hardening process. Colorful wood to match any decorating scheme without recourse to paint is the result. Tough, scar-resisting colored floors matching the rugs or the room tone are now possible.

Other wood you will be using and seeing will be built up of thin sheets and small pieces, stuck together with various glues, resins and "gunks." These are the plywoods, veneers, and laminates of yesteryear, vastly improved and remodeled. Ordinary ply-



woods of the past were suitable for indoor use out of the wet. Modern plywoods are the weather resisting material of war craft, such as the British Mosquito bombers and our own PT boats. The binders are now synthetic resins that set under heat and pressure and make a joining that is stronger than the wood itself.

The development of phenolic resin glues which resist moisture and weather has made possible large structures of laminated timber, such as bridges and blimp hangars.

In the household and factory of tomorrow wood will be used both as veneer and base material of almost everything from walls to kitchen sinks. Wood sheets as thin as 1/48 inch can be cemented to steel, aluminum or other sheet metal and the combination bent, cut and stamped. This wood-faced metal will be used in paneling for walls in offices and homes, airplane cabins, streamlined trains and even automobiles. And turn about, it is possible to bond a thin stainless steel sheet to a birch plywood base to make such things as a modern kitchen sink that will be dent-free and lighter than the conventional sort at about three-fifths the cost.

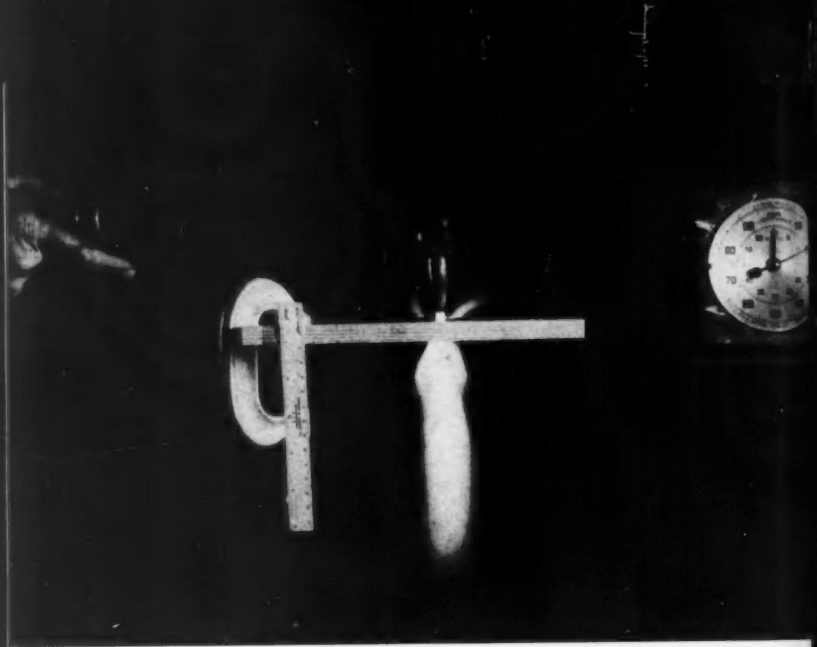
Sandwich wood, which uses one kind of wood for a core and another for surfacing, will find new uses for wood. Already light balsa wood sandwiched between a hardwood veneer is used in building the British Mosquito bombers, and similarly fabricated board may insulate your future home.

The astonishing new method of gluing anything to anything else, called "cyclewelding," works on wood as well as metal. When it is no longer needed to replace rivets by the millions in warplanes, it will revolutionize many construction methods in peace-time production.

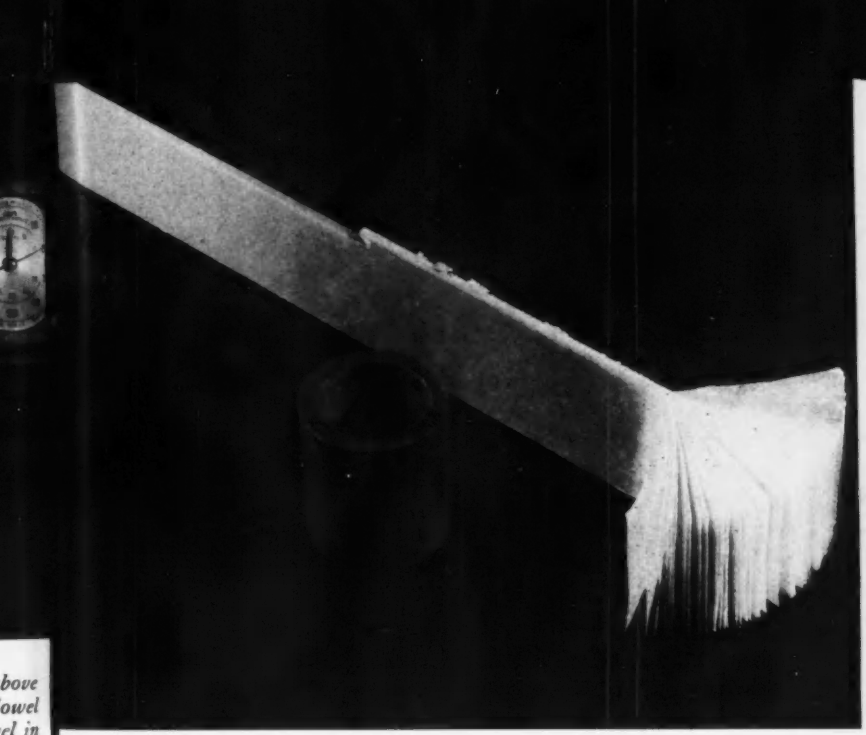
➤ HER COAT *is made of wood fiber, like the sample in her hands.*

Termites, insidious molds, and that carelessly abandoned highball glass do not harm the kind of built-up wood called "impreg" by the scientists of the U. S. Forest Products Laboratory who figured it out. Sheets of veneer are impregnated with a water solution of phenolic resin-forming chemicals, and then bonded together with heat.

This impreg squeezed to half its size during the heating process, changes into "compreg," a sturdy product used



➤ FIRE AND WATER *are not disastrous to the new woods. The blowtorch above burns a clean hole, with no flame where it is not wanted. The untreated dowel below swells in water and holds the ring tightly, but the warp-proof dowel in the operator's hand lets the ring slide freely wet or dry.*



➤ PAPREG *is built up from sheets of special paper.*

in the war for airplane propellers, plates that must carry heavy loads and tool parts in aircraft factories. Because compreg has a naturally highly polished, extremely hard surface, undamaged by water, alcohol or mild acids, it promises to appear in the future in fine furniture, tables, the tops of bars and flooring.

Wood which will always retain its compressed thickness when the atmospheric moisture has dried out is made by bottling up in the wood when it is compressed the desired amount of moisture. Called "staypak," it is stronger than all compregs.

Then there is "papreg" made of resin-impregnated layers of paper pressed together, so strong that it is competing with aluminum sheet metal in planes and ships. This improved paper, made from wood, becomes a new building material.

The cellulose of wood, used as paper, transparent sheeting, rayon and a thousand other chemical products in war and peace, has lignin as a partner in the tree. This lignin is the binding material of the wood and millions of tons of it have been wasted. Lakes of lignin have flowed unused from pulp mills, polluting streams and rivers. Soon the chemist will find this discarded stuff a source of riches as useful as cellulose itself. Already it is used in making a low-cost black plastic.

➤ THE NEWER PLYWOOD *may be curved into tubes for strength and beauty.*

The sawdust and shavings, still too often burned or allowed to rot, are a valuable raw material for industry. From a ton of wood waste can be made 50 gallons of ethyl alcohol needed for synthetic rubber (or any other use) along with three gallons of fusel oil and 600 pounds of that mystery chemical lignin. Or approximately 500 pounds of yeast with its protein food value can be secured from one ton of wood waste along with other byproducts.

A Cinderella of the forests may be found in a blanket you buy or a coat or felt hat that you will be wearing. In the bark of some of the oldest and largest trees on the face of the earth, the redwoods or Sequoia of California, there is fiber that can be used to replace 15 per cent to 60 per cent of the wool used in some fabrics. The short, kinky redwood fibers blend readily with sheep's wool. That old joke about wooden overcoats needs revising.

We have not come to it yet, but wood can be placed on the dinner table if the need should arise. The Germans are using wood to make cattlefood. A weak acid treatment turns cellulose into sugar. That is a step in that chemical use of wood waste. Since sugars derived from wood can be made into yeast or alcohol, wood can yield two kinds of food—sugar and yeast. And drink as well, as there is the alcohol.

All of which is quite a distance from the rough boards of your back fence or the sawdust on the floor of your butcher shop.

Rocket Powder Factory Smothers Fires Instantly

Fires With Safety

by PAUL W. KEARNEY

➤ THOUSANDS of manufacturing plants go for years without a fire. And then, very often, their first fire is their last. But in Sunflower, Kan., 35 miles west of Kansas City, there is a factory that averages 150 outbreaks a day, in one division, with a recent high mark of 259 fires in a single 24-hour period. And this factory is probably the largest powder plant in the world, packed with sudden death by the carload. Yet it has the lowest accident rate in American industry.

Sunflower Ordnance Works, built by the government, is operated by the Hercules Powder Company under the jurisdiction of U. S. Army Ordnance. Covering an area of 40 square miles, dotted with nearly 5,000 buildings, the plant's major product is smokeless powder for Navy guns and Army artillery; its most interesting product is the new rocket or jet-propulsion powder, called JP for short.

There are several other ordnance plants engaged in similar work. The Hercules firm operates a second, at Radford, Va., and a third at Badger, Wis. The Monsanto Chemical Company has charge of the Longhorn Ordnance Works at Marshall, Texas.

The 150 daily fires occur on Sunflower's JP lines, 60% of whose operators are girls. Yet so efficient is the protection provided these workers that there have been no fatalities, and only 17 "lost time" injuries, of which none was permanent.

The girls, few of whom had any previous industrial experience, are handling the most treacherous powder ever made. But with an accident frequency record of only 3.38 per million man-hours of exposure (compared to 14.85 for all industry), they are working in the safest occupation in America—actually four times safer on the job than they would be at home!

The combined Army-Navy programs now call for $150,000,000 worth of rocket powder a month. The rocket has turned out to be one of the outstanding weapon developments of this war, because of its enormous destructive power in comparison with its light weight. It used to take six horses to haul a 75-millimeter (3-inch) field gun and at least as many men to handle it. Now, with the Army's 22-pound M-12 launcher, one soldier can fire a 4.5-inch rocket whose war-head has the explosive force of a 105-millimeter (4-inch) howitzer shell. Three-tube clusters of these launchers are easily carried under each wing of a light plane.

In recent months both the Army and Navy have used rockets intensively. The Ninth Air Force has emphatically urged greater use of air-borne rockets because of the havoc wrought by them when mounted on their P-47 Thunderbolts.

In the Pacific theater both Army and Navy have had remarkable success with rockets in landing opera-

tions. About 50 PT boats or LCI's, each equipped with a score or more of rocket launchers, move in just ahead of the landing parties and from close range pour thousands of pounds per minute of the highest explosive now known into the machine gun nests on the beach, cleaning out the opposition as if with a giant vacuum cleaner.

The JP powder made at Sunflower is the propelling charge of the rockets. Loaded into steel cylinders in sticks several feet long, this powder is ignited by electrical contact. Burning at a sustained and furious rate, it generates intense gas pressure which provides the motive power to carry the missile toward its target.

It is the way it burns which makes JP powder so different from anything American powder men have ever worked with— and makes its manufacture so potentially dangerous. Thirty months ago no one in this country knew how to make it, and when Army Ordnance came to the Hercules people in August 1942, and told them to get going on a JP plant, it was a bolt from the blue. The Germans had made the stuff in 1918; the French learned from them and passed the information along to the British. In September 1942, two Hercules engineers and an Ordnance officer rushed to England for a hurried tour of British plants that make the powder. A month later they returned with formulas and a complete description of the technique.

The Americans saw ways to improve on British production. Nearly every time-saving change, however, introduced greater risk and called for more elaborate safety precautions. For example, after the British mix the powder they dry it for 24 hours before rolling it; our men reasoned that by heating the rollers, the stuff could be dried and rolled in one operation at a great saving of time.

JP is nearly 50 per cent nitroglycerin as contrasted with a maximum of 20 per cent in other powders. The proposal that it be pressed by heated rollers and extruded dry under tremendous pressure, was appalling. But so were the production figures anticipated by the armed forces. Accordingly, the safety men were called in to take out the risk without curtailing the output.

About five months after the engineers returned from England all plans were completed and construction began on the first JP line at Sunflower. In July 1943—just 11 months after Hercules was asked to make something never before attempted in this country — the first finished rocket powder came off that line.

JP manufacture begins with the treatment of cotton with nitric acid to produce nitrocellulose or guncotton. This is mixed with nitroglycerin and other ingredients and agitated into a goo or "slurry" in huge tanks equipped with rubber-bladed beaters. If you peer into a tank your spine tingles when you realize that it is whipping up nitroglycerin and guncotton much as your wife whips up the batter for a cake. Yet the calm, unhurried efficiency of the typical powder plant, the meticulous orderliness everywhere, the calm demeanor of the experienced powder men soon dissipate your fears. Before long you even grin halfheartedly when you hear them refer to the nitro tank-cart as the "angel buggy."

The atmosphere of the place exudes that quiet confidence which tells you that these men know how close to God they are all the time, yet evidence of precautions on every side prove that they aren't missing a trick in the avoidance of trouble. Workers in danger areas are constantly spot-checked for matches; the mere possession of a "strike-anywhere" match means instant dismissal. Buildings are kept to a minimum size and spaced wide apart; even the number of occupants is rigidly restricted. If five persons is the limit posted at the door, two employes have to come out before two visitors will be admitted. To minimize confusion, only one transient at a time is permitted in some buildings. Every hazardous building is fortified by earthen barricades, 12 feet thick at the base, to divert any possible explosion upward instead of letting it spread laterally. Safety clothing; lead floors to minimize sparking hazards; escape chutes instead of stairs; and many other safeguards are apparent. Above all, the housekeeping is meticulous.

When the slurry leaves the mixing houses it is dried into a slightly moist paste and transferred to the roll houses. About six pounds of this paste is dumped onto a pair of bulky steel rollers heated to 210 degrees. Working somewhat like a clothes wringer, these rolls compress the paste into a sheet resembling a black rubber blanket. It is here that most of the fires occur.

Each girl wears a trim white uniform; powder shoes with safety toes and conductive rubber soles; gloves; a turban that covers her hair and neck; a large plastic mask which covers her entire face and has a bib that tucks into the neck of her cover-alls in order to protect her throat. All cloth garments are flame proofed; they must be laundered only at the plant laundry (free) so that the flame-proofing chemical can be replaced after each cleaning.

Every roll house—and there are scores—is a low building about 100 feet long, with a roofed porch or boardwalk running the full length. A house contains four bays, each with its rolling machine and operator; each bay is provided with two exit doors. Taking a fiber bucket of powder delivered to her at intervals by a helper, the operator walks in 25 feet from the porch to the machine, emptying the stuff on the rolls. From that moment on, no matter what else she does, she never turns her back on the machine.

She retreats to the inner door of the bay where the control levers are situated, and starts and stops the rollers several times until the powder is evenly distributed on the cylinders. She then moves in again and empties a small envelope of chemical into the powder, leaning over the machine to smooth the mixture. Backing away again, her eyes never off the machine, she reaches behind her for a broom and returns to brush off the machine and the tray under the rollers. Excess moisture underneath is swept into scuppers; the floor is cleaned of any particles of loose powder; then, walking backward as an animal tamer does in a lions' cage, she replaces the broom.

The rolls continue on their run which, in four or five minutes, will "cook" and compress the powder into its blanket form. After she has thrown

the lever, the girl backs out to the outer door, sits down in a chair on the porch to watch the timer; then—and never before then—she removes her face mask.

At the prescribed time she replaces her mask, tucks in her bib, and returns to the controls. A flip of a lever actuates a blade which slices the powder blanket off the rollers, dropping it into the tray beneath. While she does this the operator is peeping around the door jamb like a curious kid on Christmas morning, for it is during this operation that most of the fires occur.

Invariably fires are preceded by an ominous crackling which is the girl's cue to dart out like a startled gazelle. The gas pressure generated in a split second is terrific and can often be felt out in the open, 40 feet or more from the machine. One girl was pinned against the wall by it—"it felt as if a giant had grabbed me by the chest and slammed me against the boards." Another girl was bowled off her feet by the blast, and had the presence of mind to stay on the floor and roll out of the doorway.

Although there are only six pounds of powder in most of the machines (20 pounds in some), the stuff burns like a huge blow-torch. Long tongues of flame roar out, followed by clouds of yellowish, choking smoke; often chunks of flaming powder are flung in all directions. I was standing ten feet outside the outer door when I saw my first fire there, and my hat was almost blown off by the fierce gust of pressure.

This powder supplies its own oxygen as it burns, hence it can burn under water once it gets headway. A few months ago 1100 pounds of JP powder in stick form caught fire and consumed itself despite a young Niagara of water poured on it.

Even in that huge blaze nobody was injured; no machinery was damaged; even the white walls and ceiling were only lightly discolored. In the rolling machine fires the machines are in operation again, undamaged, within 20 minutes. The fire never gets beyond its point of origin. If it did it might spell the end of Sunflower Ordnance Works.

The explanation of this miracle lies in the ingenious protection system which was designed and perfected before ground was broken for the new JP powder division. C. L. Jones, Hercules safety engineer, realizing that the only hope of protection lay in the development of a supersensitive sprinkler system that would operate with a speed and volume never before dreamed of, called in the engineers of the Automatic Sprinkler Corporation of America and said, "I want you to design a sprinkler system that will operate in a half-second or less."

The engineers went home mumbling to themselves, for ordinary systems generally function in a minute or two; for special hazards they can be speeded up to operate in three seconds.

The half-second sprinkler idea was just about as appalling to them as the whole rocket powder process seemed to the Hercules men at first. However, the Automatic engineers, following Jones' suggestions, developed a system which puts a torrent of water on a fire in a half-second, and has frequently done it in one fifth of a second.

Hypersensitive detectors are set just a few inches above, below and behind the rollers of each machine. The machine is also flanked by open fog nozzles, each of which delivers 35 gallons of water per minute. Other nozzles in strategic points cover the remainder of the room and the operator. In each roll house bay are more than 24 fog nozzles, backed up by 26 or more sprinkler heads in the ceiling and all the way out to the porch. Finally, the deluge valve which turns on the water is only three feet from the machine, so that the water is always there and waiting.

When the temperature of the powder rises suddenly just before igniting, this jump is signalized by the crackling and popping which warns the girl to run. The temperature increase also causes air confined in the detectors to expand against a diaphragm. This trips the valve mechanism, permitting water to flow out of each nozzle at the rate of about 35 gallons per minute. The ceiling heads add their contribution to the deluge, blanketing the entire room and its exits. Most of the fires are put out in five seconds, with much of the powder still unburned.

New girls, who break in as helpers delivering powder, are apt to be jittery when they first go on the machines, but their nervousness invariably passes with their first fire. One girl I chatted with had had 38 fires in four months—three of them within 40 minutes on one day. Others were just as casual about it as she was. "With fires popping around you all day long," said one, "you can't help but get used to it." All of them said the worst hazard involved was getting wet and having your hair-do mussed!

A few months ago when a worker suffered a reportable injury, SOW spoiled an outstanding safety record of 1,125,000 man-hours without an accident. The fellow was a carpenter. Surrounded on every side by 40 square miles of sudden and violent death, he slipped off a roof and wrenched his back!

More Rubber; Less Marihuana

▸ BREEDING PLANTS to produce higher yields of useful substances, and lower percentages of harmful drugs has occupied the attention of Dr. H. E. Warmke and Harriet Davidson of the Carnegie Institution of Washington's division of genetics. Carrying on from preliminary results obtained a year ago, they found that they could get bigger roots, containing a higher percentage of rubber, from the Russian dandelion, kok-saghyz, if they subjected parent plants to chemical treatment that doubled the number of chromosomes in the cells of the offspring.

They have also been at work on hemp, to decrease if possible its content of the narcotic poison known in Mexico and the United States as marihuana. They announce that they have succeeded in producing a strain of hemp with materially reduced toxic properties. Eventual application of these results will, it is hoped, produce hemp varieties that can be grown for fiber and seed without the risk that now obtains, of their illicit cultivation for the bootleg drug traffic.

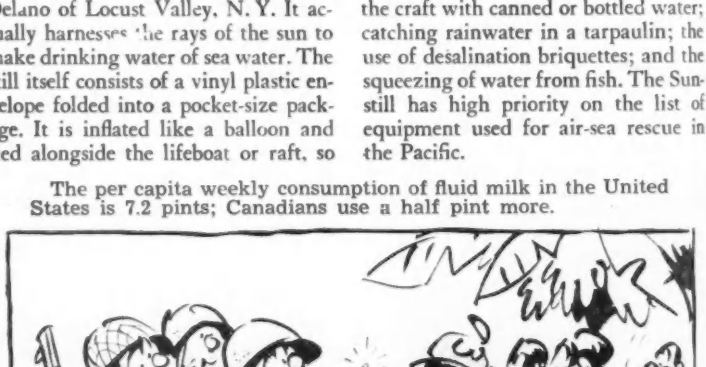
New Pocket-Size Solar Still

➤ A NEW POCKET-SIZE solar still assures a continuous supply of fresh water to Army and Navy flyers forced down in tropical waters. The still, under average conditions in the Southwest Pacific, can convert salt water into safe drinking water at a rate of more than a pint in eight hours. Under ideal conditions it can turn out almost double that amount in the same period of time.

The basic idea for the Sunstill, manufactured by the Gallowhur Chemical Company, was conceived by Richard Delano of Locust Valley, N. Y. It actually harnesses the rays of the sun to make drinking water of sea water. The still itself consists of a vinyl plastic envelope folded into a pocket-size package. It is inflated like a balloon and tied alongside the lifeboat or raft, so that it floats on the water. A black cellulose sponge, stretched through the middle of the envelope, soaks up water and absorbs the heat of the sun. Then, through evaporation and distillation, the sea water is converted into safe drinking water.

There are no moving parts, and the device will work indefinitely. Until the development of the Sunstill there were only four other methods of providing survivors with the first essential to their well-being, water: equipping the craft with canned or bottled water; catching rainwater in a tarpaulin; the use of desalination briquettes; and the squeezing of water from fish. The Sunstill has high priority on the list of equipment used for air-sea rescue in the Pacific.

The per capita weekly consumption of fluid milk in the United States is 7.2 pints; Canadians use a half pint more.



"Grin and Bear It" cartoon by Lichty—Chicago Times Syndicate

"As a token of friendship, chief, we give you this magic gold ring . . . in a week or so it'll turn green! . . . ."

Chem Quiz

All Colors of the Rainbow

➤ COLORS play an important part in chemistry. A number of elements are named for the colors of their salts or their spectrum lines. The names of these elements are called for in this month's quiz. Remember to be guided by the meaning of the name, not by the properties of the element. Give yourself a score of 10 for each element guessed correctly. Answers p. 42.

a. *Chromium* means all colors. What other element has a name of similar meaning?

b. One element whose name means violet.

c. Two elements whose names mean blue.

d. Three elements whose names mean green.

e. One element whose name means yellow.

f. Two elements whose names mean red.

New Adhesives Provide Slip-Proof Walks

➤ NEW DEVELOPMENTS in the field of adhesives include an adhesive to hold a light-weight deck covering in place, thus providing surfaces on which you can walk without slipping, for airplanes and ships; adhesives that stick rubber and synthetic rubber to metal and still other adhesives for the lamination of metal parts and plywood, Fred Wehmer, of the Minnesota Mining and Manufacturing Company has reported to the American Society of Mechanical Engineers.

"The uses to which adhesives are put are almost beyond enumeration," he declared. "The war has put an emphasis on replacement materials, and as a result many new resins and other materials are being used as adhesives."

The speaker outlined many new wartime applications for adhesives that hold promise for postwar development. Among the various types, he pointed to structural adhesives which include vulcanizing adhesives and adhesives used in laminating, or making sandwiches of metals and other materials. He also discussed the unique properties of water-dispersed resins which cut the fire hazard to a minimum and are used in combining paper and cloth and crude and synthetic rubber to give flexible materials that can be stretched to a definite degree.

The adhesive that sticks floor covering to the metal decks of airplanes and ships, providing a slip-proof walk, is particularly interesting, Mr. Wehmer remarked, because it can withstand water, and the low temperatures of high altitudes as well as the high temperatures experienced in the tropics.

Black powder, used extensively in mining, is more sensitive and ignites more quickly when it contains a small amount of moisture.

You May Be Able to Solve Some of These War Problems

Inventors Ahoy! Navy Lists Problems

➤ HAVE you a good method for welding thin aluminum sheet? Or a fungicide that will make tents and tarpaulins rot-proof in the humid tropics? Or some way to prevent cracks from spreading in steel structures, without having to use a lot of rivets and caulking?

If you have, the Navy wants to know about it. It has asked the National Inventors Council to issue a general call for solutions to 25 problems that stand as challenges to Yankee ingenuity. Dr. C. F. Kettering, chairman of the Council, has passed on the word to Americans at large, confident that the right answers will not be slow in coming up.

Some of the problems, though by no means easy, do not necessarily need specialized technical training for their solution, so much as native skill in devising things. Included in this class might be the call for some way of dropping things from planes without use of parachutes—possibly some inexpensive and expendable pneumatic cushioning arrangement. Another would be a simple, easily-run-up radio antenna about 300 feet high, requiring no steeple-jack work for its erection. Still another would be a non-slipping shoe sole for use on the wet deck of a sharply rolling ship.

One group of problems is as old as seafaring itself: the job of being on or in the water and still not getting wet. Modern angles of this old difficulty include waterproofing the openings through which small shafts connect the "works" within tight radio cabinets, generators, etc., with outside cranks and control knobs; waterproof jacks for microphones and headphones; a durable plastic-impregnated tent fabric, waterproof, lightproof, weighing less than six ounces per square foot.

Sailing at night has always involved the necessity for guiding and warning lights. Accordingly, the list includes a call for a simple, lightweight beach marker light; an improved drum-type lens that spreads a flat circle of light in all directions; a narrow-beam range light that will replace the present two-lamp installations.

Several of the desired inventions are jobs for men with professional training and experience in the fields of electrical and electronic engineering. Such are a polyphase AC motor of improved torque properties; a small DC motor without commutator, slip ring or other loose, noise-making parts; a compact, rugged, expendable mechanical device to permit successive closures of up to eight electrical circuits with a time interval between closures of about 0.2 to 0.3 seconds; a precision twin-triode vacuum tube resembling the present 6SN7 type but with improvements on it.

Concern for the safety and health of Navy men, both afloat and ashore, are reflected in several of the problems.

For example the Navy wants a fire-extinguishing liquid that will work as well as the now widely used carbon tetrachloride, without the latter's distressing trick of splitting into poisonous phosgene gas when it strikes hot metal. Another requirement is for a device that will take continuous samples of the gases in enclosed spaces, such as the bilges of boats, to detect accumulations of dangerous gasoline vapor. Still another is an efficient knapsack sprayer for mosquito control work ashore.

If you have any inventions or definite ideas along these lines, or wish a list of the 25 needed inventions giving fuller details, write to the National Inventors Council, Department of Commerce, Washington 25, D. C.

Gibbs Nominated to 1945 Hall of Fame

▶ Josiah Willard Gibbs, noted mathematical physicist, who in 1940 received 56 votes for election to the Hall of Fame for Great Americans on the campus of New York University, will again be a candidate on the 1945 ballot, Dr. James Rowland Angell, Director, announced last night.

Stating that Gibbs had lacked only nine votes to achieve the three-fifths majority necessary at the last election, Dr. Angell pointed out that songwriter Stephen Collins Foster had been the only successful 1940 candidate, in a group of 141 nominated by the public. Under the rules of the Hall of Fame, every candidate in the 1940 election who received 20 or more votes will be named automatically on the 1945 ballot.

Entering Yale University as a student at the age of 15, Gibbs became its Professor of mathematical physics in 1871 and remained there until his death in 1903. His great contributions to science were in the field of thermodynamics—that science which treats of heat as a form of energy. A paper, outlining Gibbs' theories which completely revolutionized industry, almost never saw light of day, and would not have done so, had it not been for the contributions of business and professional people of New Haven which made its publication possible. The iron and steel industry, the makers of cement and porcelain, and other industries too numerous to mention are dependent upon Gibbs' formulas and principles outlined in this paper. To Gibbs' students who did not understand his teachings, he was known affectionately as "Jibes" but to fellow scientists, he was known as the Helmholtz of this country.

The public has until April 1 to propose names of candidates for this, the tenth quinquennial election to the Hall of Fame, Dr. Angell said. During the summer, a board of electors composed of 102 distinguished citizens, representing every state, will consider the nominees, and their decisions will be announced in November. Successful candidates will be honored by a bronze portrait bust and tablet placed in the open air colonnade on the campus of New York University, University Heights — overlooking the Palisades and the Hudson and Harlem River Valleys—which serves as the physical "Hall of Fame."

Thiamin Synthesis Result of Studies Made in Philippines

Chemistry in Medicine

by JANE STAFFORD

Beriberi Cure Rapid

➤ CURE OF beriberi, from which Americans rescued from the Japanese prison camps are reported suffering, is usually very rapid. Improvement will come in a matter of hours after treatment is started, if the rescued men have not suffered irreparable damage to nervous system or heart.

The treatment will doubtless consist in giving large doses of thiamin, also known as vitamin B_1. This chemical, which is both cure and preventive of beriberi, was first synthesized by an American scientist, Dr. Robert R. Williams of the Bell Telephone Laboratories, as a result of studies on beriberi which he started in the Philippines in 1910.

Long before the vitamin had been isolated and synthesized, it was known to occur in foods and beriberi was known as a disease resulting from a poor diet. Ironically, one of the first persons to advocate that beriberi resulted from poor diet was the Surgeon General of the Japanese Navy, Takaki. In 1884 he was able to wipe out beriberi in that navy almost completely by changing the ration. It is reasonable to assume that the rations of Japanese sailors and soldiers today contain plenty of the anti-beriberi vitamin.

Orientals living chiefly on rice are likely to get beriberi because they eat polished rice. The polishing removes the thiamin from the rice, just as thiamin is removed from wheat in the processing of our fine white flour. To overcome this, our bread is now enriched by addition of thiamin as well as other vitamins and iron.

Beriberi has been considered relatively rare in the United States, but one authority writing in 1943 stated that this is not true. The symptoms of the disease vary greatly. They include neuritis, muscle weakness and wasting, loss of coordination and of sensation, dropsy, and, when the heart is affected, difficulty in breathing, pain around the heart, blue color of the skin and rapid pulse.

Treatment of beriberi includes feeding a good diet as well as giving doses of the vitamin, thiamin. In this country, persons who had been eating such a poor diet that they got beriberi would probably also suffer from lack of other B vitamins. In the Orient, the poor diet that leads to beriberi apparently does not lead to other vitamin deficiencies.

For the people rescued from Cabantuan and other prisons, the diet may consist in frequent small feedings of concentrated foods, but they are more likely to be given as much as they can eat. The danger of overfeeding is not the same for these malnourished persons as for men rescued from a life raft who have had nothing to eat for 30 days. Such persons cannot eat a lot all at once, probably because their

digestive functions have been impaired. This is not so true in cases of vitamin deficiency and general malnutrition.

Chemical from Two Vitamins

➤ A REMEDY for muscular dystrophy may come from a new chemical to be made from two vitamins, it appears from research reported in Science by Dr. Ade T. Milhorat and Dr. W. E. Bartels, of Cornell Medical College and New York Hospital.

The vitamins are tocopherol, also known as vitamin E and as the fertility vitamin, and inositol, one of the B vitamins. Neither of them alone is expected to be helpful. Large doses of both given together may help patients with a mild form of the disease. For those in whom the disease is more rapidly progressive, the new condensation product of the two vitamins will be needed, the doctors believe.

Whether this product actually will help patients cannot be stated at present because the doctors have not had enough of it for trial. They hope to get and try it soon.

Laboratory tests and studies of animals are the basis for the hope that the condensation product of tocopherol and inositol will be an effective remedy for progressive muscular dystrophy. This disabling disease is characterized by marked weakness associated with degenerative changes in the affected muscles. There is also an abnormal excretion of the chemical, creatine.

Creatine is present in muscles as part of the compound, phosphocreatine. When muscles contract, this compound breaks down into creatine and phosphoric acid. In the recovery of the muscle the two substances are recombined into phosphocreatine.

The Cornell scientists had just enough of the new chemical to try the effect of single doses in a few patients. The abnormal excretion of creatine was reduced for a few days, which encourages them to believe that continued treatment will prove helpful.

Muscular dystrophy very similar to that in patients can be induced in laboratory animals by withholding tocopherol from their diet. Doses of tocopherol by mouth promptly reduces the abnormal creatine excretion and restores muscular function in the animals.

Tocopherol alone has no effect in human patients. The reason, apparently, is that progressive muscular dystrophy results from an inherited defect in the body's handling of tocopherol and inositol in food. Normally the condensation product of these two substances can be made in the body but patients with muscular dystrophy lack the ability to make the product.

Patients with a mild form of the disease apparently can make enough of the product if given large amounts of the two vitamin chemicals. Those with a more severe form of the disease cannot. For them the new chemical, if it comes up to expectations, will be what insulin is to diabetics.

Penicillin and Albumin

➤ MORE effective penicillin treatment may result from a new penicillin substance announced by Dr. Bacon F. Chow and Miss Clara M. McKee, of the Squibb Institute for Medical Research, New Brunswick, N. J., in a recent issue of Science.

The new substance is a combination of penicillin and the albumin of human blood serum. Its promise of increasing the effectiveness of penicillin treatment is seen in the fact that, in mice at least, it is excreted from the body more slowly than the sodium salt of penicillin, the form of the mold chemical used for treating patients. The more slowly penicillin is excreted, the longer it can act on infecting microorganisms and the less is needed for treatment of a given case.

Several other methods of delaying penicillin excretion have been developed. This is the first report, the Squibb researchers believe, of a penicillin compound with a delayed excretion rate. The other methods involved suspending penicillin in oil, giving other chemicals with penicillin, or chilling the region where penicillin was injected.

Whether the penicillin-albumin combination is a true chemical compound is not yet known. The fact of its slower excretion suggests that it is. Unlike a similar combination of albumin and sulfa drugs, which some investigators believe has no germ-checking activity, the penicillin-albumin combination does have anti-germ activity.

Penicillin for Heart

➤ PATIENTS with the kind of heart disease known as subacute bacterial endocarditis, heretofore almost always fatal, should be treated with penicillin if the heart ailment is due to a streptococcus sensitive to the drug.

This advice is given to the medical profession in a report by Dr. Martin Henry Dawson and Dr. Thomas H. Hunter, of Presbyterian Hospital and Columbia University College of Physicians and Surgeons, New York, in the Journal of the American Medical Association.

It is based on apparent success of the treatment in 15 out of 20 patients. These patients are in excellent health, free of all signs of the infection that caused their heart trouble, and all but three are back at work, housekeeping, or whatever their former occupations were. They might be called "cured" except for the fact that the period since the treatment was stopped is only a matter of months and in a chronic disease such as this more time is needed to be sure the germs causing the trouble have really been defeated.

Of the other five patients, two relapsed as soon as treatment was stopped but they are in excellent general condition and the doctors hope they will yet be able to cure them. The other three patients died. In two cases the infection was still present at the time of death and in the third the situation was doubtful.

Since the report on the 20 patients was written, seven more have been treated. Of these, six are well and one relapsed and is now getting additional treatment.

Drs. Dawson and Hunter first used penicillin to treat subacute bacterial endocarditis in 1942 and 1943. The results were encouraging but because supplies of penicillin were then so limited, only two got enough to make recoveries. Another two have since been treated with larger doses combined with the anti-blood-clot chemical, heparin, and they also have now recovered. The fifth died of stoppage of a blood vessel in the brain but post mortem examination showed "sub-

stantial healing" of the heart condition.

Besides giving much more penicillin to the patients treated during the past year, heparin was also used. The combination of penicillin and heparin was first tried by Dr. Leo Loewe and associates at the Jewish Hospital, Brooklyn, N. Y.

They tried heparin, with good results, because the germs that cause subacute bacterial endocarditis grow on the lining membranes of the heart in clumps mixed with fibrin from the blood. Buried in these clumps or clots, the germs are protected from chemical remedies circulating in the blood. Heparin counteracts the tendency of the blood to form clots in which the germs can grow safely and so should make the germs more vulnerable to attack by penicillin.

Drs. Dawson and Hunter found, however, that in five cases they got as good results without heparin as with it in other cases when large doses of penicillin were used. Giving this drug by continuous drip into the muscles instead of into the veins or by repeated injections into the muscles keeps more of it in the blood and is more comfortable for the patient, they report, as well as simpler when penicillin must be given over prolonged periods.

Sulfadiazine Prophylaxis

➤ EPIDEMICS of streptococcus sore throats and scarlet fever that threatened an Army Air Force technical school were prevented and cases of these ailments reduced almost to zero by sulfadiazine prophylaxis, Capt. Richard G. Hodges of the Army Medical Corps reports in the New England Journal of Medicine.

Cases of pneumococcal pneumonia were also significantly reduced, as were attacks of ordinary respiratory disease which the layman would call a cold. Rhinitis, pharyngitis, laryngitis and acute bronchitis were included in this group.

The effect of sulfadiazine prophylaxis in reducing these ailments, Capt. Hodges suggests, is probably because a fair proportion of them were caused by bacteria and not by the virus of the common cold, although their symptoms would lead the layman to label them as colds.

The results reported were achieved last winter at an AAF technical school located in the midwestern part of the country. A severe epidemic of respiratory diseases including strep sore throats and pneumococcal pneumonia had struck this school during the winter of 1942-1943 and did not die down until May. When in January 1944, these epidemics threatened a repeat performance, the decision was made to try the effect of sulfadiazine prophylaxis.

Different schedules for giving the drug were tried. One of these called for daily small doses for a prolonged period. Another called for twice this sized dose on two consecutive days each week. It is believed, Capt. Hodges reports, that the best dosage for a given group should be worked out individually.

No serious reaction to the drug occurred. Patients with pneumococcal pneumonia who had been given sulfadiazine prophylactically seemed to respond as well as ever to the drug when given as treatment.

"The most convincing information yet published" on the effects of sulfa-

diazine prophylaxis, comments the editor of the New England Journal of Medicine, appears in that part of Capt. Hodges' report showing a continued rise in streptococcal infections in the group of men not getting the drug at the same time that these infections dropped sharply in the group on prophylaxis.

Possible dangers of mass prophylaxis with sulfadiazine are stressed by the editor. One is the possibility of men becoming sensitized to the drug so that they will not be able to take it as a remedy if they should require it for some illness. Another is the development of resistance to the drug by the streptococci. One group of scientists has already reported that they could not control by sulfa drug prophylaxis the spread of a drug-resistant streptococcus in a measles ward.

Possible effects of sulfa drug prophylaxis on the heart must be considered, the editor points out, since deaths as the result of heart muscle changes following treatment with sulfa drugs are apparently increasing. It is also possible that getting protection against disease germs at one time may result in continuing susceptibility to the germs and the "development of appreciable patterns of illness on later exposure to infection.

"Military necessity will, of course, dictate the continuation of sulfonamide prophylaxis," the editorial comment continues. "Even in such populations the alleviation of an immediate problem may ultimately prove to affect adversely the future health of service personnel.

"So far as civilian populations are concerned, there seems little justification for the wholesale and uncontrolled use of long-continued sulfonamides, save on a purely experimental basis, with a carefully thought-out and controlled study.

"Furthermore, attention should be directed to other measures for the control of streptococcal infections that are not accompanied by the dangers and difficulties mentioned above. Dust control (by the oiling of floors and bedclothes), sterilization of the air by ultraviolet irradiation and the use of aerosols, ventilation, improved methods of housing and so forth may be mentioned as procedures of probable benefit."

Gamma Globulin for Jaundice

➤ Blood donated to the Red Cross to save the lives of our wounded fighting men may also provide a weapon to protect them against infectious hepatitis or infectious jaundice, which is said to be one of the most important diseases of the present war.

The blood's weapon against jaundice is the gamma globulin which is also medical science's latest weapon against measles. Promising results with gamma globulin in jaundice are reported by Dr. Joseph Stokes, Jr., of Philadelphia and Capt. John R. Neefe, of the Army Medical Corps, in the Journal of the American Medical Association.

The gamma globulin is obtained from blood as a by-product in the processing of human albumin for treatment of shock. It was tried during an epidemic of jaundice in a summer camp for boys and girls last summer. It was given, by hypodermic injection into the muscles, to 53 out of 331 persons who at the time showed no signs of the disease, though the epidemic had been under way for over two

weeks. About one-fifth, 20.8%, of those injected got sick compared with 67% among the untreated who developed hepatitis. None of the 53 treated, however, developed visible jaundice of the skin although three girls showed yellowing of the whites of their eyes.

The gamma globulin can apparently either prevent the disease or reduce the severity of an attack if it is given soon after a person has been exposed to it. This is comparable to its effect in measles. It might also be useful in treatment of jaundice if given before the skin-yellowing stage, the doctors suggest.

"The results obtained in this epidemic are sufficiently encouraging to warrant further trials of gamma globulin in the control of future epidemics of this disease," Dr. Stokes and Capt. Neefe state. "This is especially desirable because no other effective control measures have as yet been developed."

African Sleeping Sickness

➤ A NEW chemical weapon against African sleeping sickness is announced in Science, by Dr. Harry Eagle, of the U. S. Public Health Service and Johns Hopkins University.

The chemical is gamma-(p-arsenosophenyl)-butyric acid. Large-scale field trials, planned to include over 1,000 patients, were started last summer with the collaboration of the Sleeping Sickness Services of the Gold Coast, Nigeria, the Belgian Congo and the British Forces in West Africa.

Results of treatment of more than 200 patients so far show that with this drug it may be possible to cure patients in the early stages of the disease in less than two weeks. Treatment with other drugs may have to continue for as long as 12 or 15 weeks, according to some published reports. Results with the new drug in treatment of late stages of the disease are not encouraging, however.

The new drug is given by injection into a vein. In the field trials it was given twice weekly, three times weekly and daily, the variation being planned to determine the best schedule. More than 800 injections of it were given to over 100 patients, with no toxic reactions except for occasional nausea and vomiting after about 2% of the injections.

The drug seems to be active against strains of trypanosomes, the germs of African sleeping sickness, which are resistant to the widely used sleeping sickness remedy, tryparsamide, and other arsenicals. It may be effective against some, though not all, forms of the disease in animals.

Mass treatment of this widespread scourge of tropical Africa may be greatly simplified, Dr. Eagle suggests, and considerable time and money saved by this new drug.

Streptomycin for Tuberculosis

➤ STREPTOMYCIN, one of the newest of the germ-against-germ medical weapons, can exert a "striking suppressive effect" on tuberculosis in guinea pigs, Dr. W. H. Feldman and Dr. H. C. Hinshaw of the Mayo Foundation and Clinic report.

What effect it might have in suppressing tuberculosis in humans is not stated in their report, just published in the Proceedings of the Staff Meetings of the Mayo Clinic.

Streptomycin, which is obtained from a bacillus that lives in earth, was

discovered by Dr. Selman A. Waksman, Dr. Albert Schatz, Dr. Elizabeth Bugie, of Rutgers University and the New Jersey Agricultural Experiment Station. They found it a powerful weapon against tuberculosis germs in test-tube experiments and suggested the guinea-pig trials to the Mayo group, which has been investigating the anti-tuberculosis action of other new antibacterial substances.

Streptomycin, they found, does not have any toxic effect on guinea pigs. The animals can stand daily doses without any harm. Doses of human tuberculosis germs that caused widespread and destructive infection in the bodies of untreated guinea pigs caused hardly any detectable signs of disease in the animals that got daily doses of streptomycin.

Battery Valve Prevents Spilling

➤ CORROSIVE ACIDS from electric batteries cannot spill out and cause battery failure or damage to the plane on batteries equipped with a new valve vent.

In combat flying, pilots frequently have to turn their planes upside down, causing battery acids to spill out.

The new valve vent, developed by the Auto-Lite Battery Corporation, seals the cells of the batteries in military aircraft when the plane is in any position but normal, as in a steep bank or upside-down flying. At the same time, it allows for perfect functioning by automatically opening the instant the plane returns to normal position.

Hydrogen and oxygen gases that accumulate while the battery is charging are thus allowed to exhaust without loss of vital battery acid.

Instrument Replaces Thumb to Test Fabric

➤ AN INSTRUMENT which will replace thumb pressure in testing the airworthiness of the fabric coverings still used on many airplanes, to determine if they should be repaired or replaced, has been developed at the National Bureau of Standards. It is a spring-driven hammer that propels a plunger against the surface being tested and measures the resistance of the fabric to penetration by impact.

In testing the fabrics, panels were prepared with different weights of cloth, with untreated cloth and cloth chemically deteriorated to known degrees, and with standard, semi-brittle and brittle dopes, or liquid finish, all applied in different amounts. Results of tests with the instrument agree closely with the strengths of the doped cloths and the quality of the dope on them.

Nylon, now used for insulation on electric wires, has many advantages, being resistant to fire and to most solvents except alcohol.

The first shipment of bergamot oil, since prewar days, arrived recently from Italy. It is made from the rinds of the bergamot, a citrus fruit, and is used as a base for eau de Cologne and in lotions, hair tonics and soap.

Dust-Free Technique Required In "Pouring" Warplane Windows

Bomber Blisters Optically Perfect

➤ MEN WHO DROP bombs and fire guns from our war planes must have optically perfect windows to sight through. When enemy fighters come boring in there must be no "wavy" spots to spoil the gunner's aim.

Therefore, the task of making these windows out of transparent "Lucite" methyl methacrylate resin involves a constant vigil against dirt, air bubbles, water marks and other factors that would cause imperfections. For example, the process of "pouring the syrup," plastics plant jargon for casting the plastic into sheets, takes place in rooms so immaculately clean that the fussiest housewife couldn't find a speck of dust. Every worker is an inspector, and when the sheeting is finally finished, the official inspectors check it again for some 28 different kinds of defects. "Wavy" spots just don't get through.

In two "Lucite" sheeting installations operated by the Du Pont Company—its own plant at Arlington, N.J., and a government-owned facility at Leominster, Mass.—well-planned techniques and careful, conscientious employees combine to achieve a high yield of product meeting the exacting specifications of the armed forces.

"Lucite" has been so widely employed in aircraft because, though much lighter than glass, it is very tough, does not readily shatter when struck by a bullet. No jagged edges remain when it breaks. An additional advantage is that it is even more transparent than glass.

Turning out a perfect product is not easy, however. "Our troubles come in parts per million," as F. D. Dean, manager of the plant at Leominster, expresses it. "If the catalyst used in making 'Lucite' is contaminated by one part of iron per million, the whole batch of methacrylate polymer will be ruined. Impurities appear in such infinitely dilute concentration that known methods of analysis are frequently useless. You only know they are present by the damage they do. This is why we have to be so painstaking in handling our ingredients and our product through the various steps of manufacture."

Production of "Lucite" starts at the Du Pont high-pressure synthesis plant at Belle, W. Va., which makes the thin, watery liquid known as methacrylate monomer, consisting of small molecules. This chemical is one of several important synthetics derived from the elements of coal, air and water.

An inhibitor is added to the monomer at Belle to prevent premature polymerization (linking of small molecules to make giant molecules) during shipment. When the monomer arrives at the sheeting plant it must therefore be distilled to remove the inhibitor. The monomer is now held in refrigerated vessels until it reaches the point where polymerization is desired. A

catalyst, which facilitates the molecule building is introduced and polymerization is allowed to proceed until a certain percentage of the material is in the form of giant molecules. It must be sampled from time to time to test its viscosity, or consistency—the higher the viscosity the further the polymerization has progressed. A standard test consists of timing the movement of an air bubble from the bottom to the top of a test tube of the "syrup." The thicker the syrup the slower the bubble.

The tempered glass plates which make up the casting mold are first put through a glorified dish-washing machine. It is designed and built for this particular task, and has an air-blast dryer which leaves the glass surfaces surgically clean. The slightest mote of dust or a finger print would show itself as an imperfection in the surface of the "Lucite" sheet. "Lucite" is sensitive to light during the casting stage and acts much as a photographic negative. A worker once leaned on a clean glass plate and after the sheet had been cast a perfect shadow picture of his arm and hand remained on the surface.

The edges of the mold are formed by a flexible gasket. The mold is held in shape with small clamps, and while it is being assembled the girl operators take care not to touch the casting surface with their fingers. They become expert at turning over the glass panes, which are about four feet square, by gripping only the edges and using their finger tips. They also deftly remove bubbles, sometimes using a paper clip and a magnet to draw an air bubble out to the edge.

After other groups of girls pour the "Lucite" syrup into the molds, in weighed amounts, the thickness is adjusted with gauge blocks and clamps, and the sheets are slowly moved through a 60-foot long oven, where the polymerization is completed and the solid sheet formed. The time in the oven depends on the thickness of the sheet.

To loosen the bond between the glass and the newly made plastic, so that it can be removed from the mold, workers spray hot and then cold water on the molds and give them a resounding whack with a wooden mallet. The tempered glass doesn't break under this punishment, but it does separate from the plastic sheet, which is then weighed with a precision recording scale. It next goes through a heat-treatment oven, in which all internal stresses and strains are removed as the sheet becomes limp and flexible.

After cooling and hardening on flannel-covered flat boards, the sheets are taken to the inspection department, where a beam of light passed through them reveals imperfections not noticeable with the unaided eye. Thickness is checked with calipers.

The finished sheets are protected with an adhesive masking paper of a special type, which will strip off without leaving a sticky residue. Power saws are used to trim the edges of the masked sheets or to cut them into smaller pieces for landing-light lenses and similar items.

The sheeting is shipped to other manufacturers for fabrication into bomber noses, blisters, panels and other transparent fittings. Some of the "Lucite" is combined with another Du Pont plastic, "Butacite" polyvinyl butyral resin, in a three-layer sandwich

(the "Butacite" in the middle) to form gun turret blisters for high altitude planes equipped with pressurized cabins, including the B-29. The laminated structure is unusually resistant to extreme pressure differentials where rupturing or shattering has been a difficulty, and to temperatures of –50°F. or lower. A 50-caliber machine gun bullet makes only a small hole, which the interlayer tends to self-seal or which can be quickly patched to retain the pressure inside the cabin.

From start to finish the manufacture of "Lucite" requires the closest teamwork between engineer and chemist. The chemistry is complicated and the control of the molecule building process is exacting. The methyl methacrylate monomer produced from coal, air and water by high-pressure synthesis is a compound containing carbon, hydrogen and oxygen. It has a molecular weight of 100 and boils at approximately the same temperature as water. When the individual molecules begin to link up they form a whole series of long-chain molecules or polymers, each having a molecular weight of 100 more than the next smaller one.

"This molecule-building is intangible and invisible, and in the difficult task of controlling it we frequently work in the dark with our gloves on," Mr. Dean remarked. "Different members of the molecular series vary markedly in properties. Some are liquid, some solid. Some soften at low temperatures, some at very high temperatures. Some are soluble in certain solvents, some quite insoluble. Some are strong, others weak. Some are hard while others are quite soft.

"We are unable to make any specified member of the series. We are obliged to make a product which contains a fairly large number of members. We cannot pick out a point; we have to take a section. But by observation of what happens, by overcoming our troubles, by improving our technique, by learning what not to do, we accumulate gradually a large amount of information. And so we gradually narrow down the section, dropping out members of the series which give the product unwanted properties."

The final product is one of the most unusual developments of 20th Century chemistry, an extremely transparent plastic, light and tough, and easily molded into shapes. It has been a strategic material in air warfare, and it is destined to find increasing use in the industrial and consumer fields after the war.

Over 10,000,000 tons of sulfuric acid are required to meet America's needs in 1944; superphosphate, chemicals, and petroleum refining, in the order named, are the biggest users; the steel industry and munitions are also heavy users.

Carbon dioxide, absorbed into the system by smokers who inhale, often causes as much as 7 per cent hemoglobin of the blood to be rendered ineffective.

Twenty tons of pulpwood sent from New Zealand to the New York State College of Forestry will be used to determine if a satisfactory chemical pulp for book and writing paper and for rayon can be made from it; the wood is Monterey pine.

Patents in Chemical Field Point to New Progress

"Patented U. S. A."

AMONG *the several thousand patents issued by the U. S. Patent Office each month there are many devoted to chemical processes and apparatus. Some of them are reported in this article. Anyone may obtain a copy of a patent by sending 10 cents in coin (not stamps) to the Commissioner of Patents, Washington, D.C., and asking for the patent by number.*

Polymerization of Styrene

➤ PATENTS on chemical processes are numerous and prominent in the recent output of new inventions. Two of them are on different approaches to the same problem, the polymerization of styrene. Styrene, familiarized to the public through its role in the formation of GR-S synthetic rubber, is useful in the production of other synthetic gums and resins as well, when its relatively small molecules are chemically welded together into bigger ones.

Both of the patents have to do with the use of catalysts to promote this making of big molecules out of little ones. One, issued to V. H. Turkington of Caldwell, N. J., and L. R. Whiting of Woodbridge, N. J., covers a process wherein the catalyst is a mixture of boric and oxalic acids. Rights in the patent, No. 2,367,810, are assigned to the Bakelite Corporation. The other, on which patent 2,367,805 was granted to R. B. Semple of St. Louis, involves the use of a catalyst made by combining hydrogen peroxide with tertiary butyl or other alcohol. Rights in this patent are assigned to the Monsanto Chemical Company.

Recovery of Phenol

➤ PHENOL, an extremely important organic compound used on a huge scale in plastics, explosives, disinfectants and other chemical products, can be produced by oxidizing benzene in its vapor phase. W. W. Moyer of Decatur, Ill., and W. C. Klingelhoefer of Van Buren, N. Y., have developed a process for recovering this vaporous phenol by washing it through liquid benzene. Patent 2,367,731, protecting this process, is assigned to the Solvay Process Company.

Spray Coating of Mirrors

➤ A SIMPLER kind of inorganic chemistry is involved in a method for silvering mirrors, offered by two Canadian inventors, Charles Trevail and Kurt P. Gladney of London, Ont., for patent 2,367,903. Over the surface to be silvered a fine spray is released, in which silver nitrate solution is mixed with a reducing solution containing hydrazine sulfate and the sulfate of one of the alkali elements such as potassium or ammonium. Patent rights are assigned to Hobbs Glass, Ltd., of London, Ont.

New Lemon-Juice Product

➤ A NEW LEMON-JUICE product, in which the labor and expense of producing commercial citric acid is bypassed, has been developed by a trio of California inventors, H. T. Leo, C. C.

Taylor and J. W. Lindsey, all of Anaheim, who have obtained patent 2,367,789. They ream out the lemons to get the juice, sterilize it and add sugar, filter the syrup to remove colloidal and suspended matter, then spray-dry it. Rights in their patent are assigned to Mutual Citrus Products Company.

Air-jets Wipe Windshields

➤ WHIRLING JETS of air under high pressure are substituted for the familiar rubber-edged arm of the automobile windshield wiper in a device for keeping the windshields of aircraft clear of water and ice, on which W. N. Patterson of Detroit has received patent 2,367,426. To make sure of dislodging the ice in winter, small quantities of alcohol or other non-freezing liquid are injected into the air-jets.

Molding Thermoplastic Domes

➤ ANOTHER INVENTION of interest to the aircraft industry is covered by patent 2,367,642, issued to Edward L. Helwig of Bristol, Pa., assignor to Rohm and Haas Company. It consists of a simple method for making structural domes out of transparent thermoplastic sheeting. The plastic material, heated to softness, is stretched across the top of a suitably deep drum and gasketed down at the edges. Air is pumped out of the drum, whereupon the outside air, under ordinary atmospheric pressure, bends the sheet inward to the desired curvature. Or, air under pressure may be pumped into the drum, blowing the dome into shape like a huge soap-bubble.

Chemical Prospecting for Oil

➤ To SCIENTIFIC methods now in use for finding oil and natural gas, add a soil-analysis procedure on which patent 2,367,592 has been issued to Eugene McDermott of Dallas, Texas. Gases from the deposits, slowly seeping toward the surface in the course of centuries, have carried with them certain minerals and left them in the soil. Mr. McDermott determines the concentration of these chemicals, especially the sulfates and the chlorides, from numerous soil samples collected over the area to be prospected. From a chart of their concentrations he determines the probable location of the pool.

High-Temperature Lamp

➤ SMALL MERCURY-VAPOR lamps designed to operate at very high temperatures—hotter even than fused quartz will stand—are the subject of patent 2,367,595, obtained by John W. Marden of East Orange, N. J. To stand up against such temperatures, highly refractory materials such as fused magnesia or alumina are introduced into the quartz envelopes, either as sleeves or baffles. Rights in the patent are assigned to the Westinghouse Electric and Manufacturing Company.

Rubber in Fuses

➤ SIMPLIFICATION of artillery shell fuses is the objective of the invention protected by patent 2,367,246, granted to W. E. Thibodeau of Cleveland and G. J. Kessenich of Madison, Wis. In most such fuses, the striker is prevented from coming into contact with the primer charge until after firing by a mechanical barrier held in place by springs. When the shell is spun by the gun's rifling, centrifugal action forces the springs back and permits the arming of the fuse. The present invention substitutes a collar or hollow cylinder of soft rubber for the

more complicated weight-and-spring arrangement. The rubber itself is deformed by the centrifugal action, permitting the free passage of the striker.

Tracer Shotgun Shell

➤ BODING ILL only to night-flying geese (or possibly also to night prowlers around chicken-coops) is a shotgun shell equipped with a number of luminous tracer pellets, the invention of Newland Knight of Mobile, Ala., patent 2,368,029. It differs from tracer shotgun ammunition heretofore proposed in having its tracer elements fixed on a separate wad that may be affixed to the front of an ordinary shotgun shell, instead of having them mixed with the main charge. The new method gives the user his choice of using tracer ammunition or not, without having to carry special shells.

Lead Iodide

➤ MANUFACTURE of lead iodide, a compound with a number of important industrial applications, is simplified in a process on which Dr. Harold A. Beatty, of the Ethyl Gasoline Corporation, received patent 2,366,953. His method consists in bubbling a mixture of iodine vapor and nitrogen or other inert gas through molten lead. The inert gas takes no part in the reaction, but serves to keep the lead stirred up; changing its proportions also regulates the rate of reaction.

Treatment for Rubber Latex

➤ IMPROVED treatment for rubber latex, to get rid of trouble-making proteins by alkali treatment, is outlined by a Dutch chemist, J. H. E. Hessels, in patent 2,367,120. By heating the latex under pressure and later adding a stabilizing compound, the inventor has been able to accomplish his purpose with a far lower concentration of alkali than has been customary.

When the patent was applied for, Mr. Hessels' address was Klein Soengei-Karang, Sumatra; since the Netherlands Indies were overrun by the Japs, the patent is now vested in the Alien Property Custodian, and is available to American users on payment of a moderate fee.

Fluorescing Marker for Coal

➤ AS A MEANS for sure identification of coal, crushed rock and similar bulk materials, R. E. Miskelly of Plymouth, Mass., proposes to spray them with a chemical that fluoresces on being irradiated with ultraviolet light; he has received patent 2,367,040 on this invention. The ordinary daylight appearance of the commodity is not changed, yet a means is thus provided for protecting it against theft, adulteration and other abuses.

New-type Heated Tank Car

➤ A NEW-TYPE tank car that can be heated to liquefy solidified contents, such as caustic soda and other chemicals, is the subject of patent 2,367,018, issued to Wesley R. Gerges of Philadelphia and assigned to the Allied Chemical and Dye Corporation. Earlier-type heated tank cars depended on steam coils or burners with flues; these tended to build up dangerously high temperatures and vapor pressures with some chemicals. Mr. Gerges uses instead a series of U-shaped conduits. Hot gases blown through these cause melting to start at the top of the car and progress slowly downward through the mass of solidified chemical, thereby minimizing risks.

Magnesium Processing

➤ THERE ARE two patents on processes involved in the magnesium industry, both assigned to the Dow Chemical Company. The first, No. 2,366,168, issued on the application of P. W. Bakarian of Midland, Mich., is on a method for bonding magnesium-alloy sheets together by first applying a very thin coating of zinc, cadmium and alloys thereof, then heating to about 600 degrees Fahrenheit and putting through pressure rollers.

The second patent, No. 2,366,185, was obtained by H. A. Diehl of Bay City, Mich., and J. C. McDonald of Midland, Mich., on a method for rolling composite magnesium-base sheets, at temperatures between 750 and 900 degrees Fahrenheit. The method is considered most useful in giving high-strength magnesium alloys a facing of a corrosion-resistant alloy.

Two-level Seed Planter

➤ A SEED-PLANTING machine that insures germination whether the season be wet or dry is the device on which patent 2,366,389 was granted to B. M. Deavenport of Clarksdale, Miss. The idea is very simple. A suitable blade draws a furrow, at the bottom of which a row of seeds is deposited. Immediately following is a big, blunt-toothed wheel, which pushes some of the seeds down a few inches, leaving the others at the original level. So if the season is dry, the deeper-planted seeds have the better chance for survival; if wet, the more shallowly-placed ones.

New Glass Resists Hydrofluoric Acid

➤ A NEW GLASS for laboratory utensils, acid containers, safety goggles and other purposes in which protection against the action of hydrofluoric acid is essential has been developed in the laboratories of the American Optical Company. It is the first known glass to offer major, desirable resistance to the attack of this powerfully corrosive acid, which disintegrates ordinary glass, destroys most metals, and produces dangerous burns on human flesh.

The discovery of the new glass is expected to simplify the handling of this industrially important acid, which is used extensively in scientific laboratories, and in such industrial operations as the pickling of metals, etching of glass, processing of textiles, manufacture of fluorides and ceramics, and as a catalyst in oil refining and synthetic rubber manufacture.

The new glass contains no sand, the basis of all commercial glasses. Its major ingredient is phosphorus pentoxide, which by itself reacts with water instantly and with almost explosive violence. The profound chemical changes that take place in making the new glass result in a product less soluble in water than ordinary glass. It is transparent and has melting and working properties about the same as ordinary glass, can be cast or drawn into sheets or blown into bottles or other shapes. It can also be ground and polished, tempered and subjected to other processes involved in glass technology without special equipment or technique.

Home-Made Laboratory Furnace

by JOSEPH H. KRAUS, *Science Clubs of America Editor*

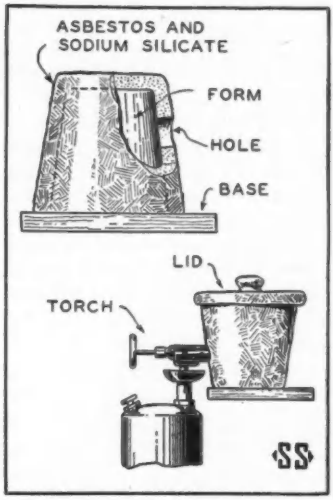
➤ A FURNACE WHICH can be built in many different styles to accommodate a variety of torches or even an electrical heating system can be built from asbestos and the popular egg preservative, sodium silicate.

Lack of such a furnace need no longer handicap the experiments in your cellar, attic or garage laboratory. Build one yourself for those experiments demanding considerable heat for completion, such as fusing chemicals, melting metals and the like.

First determine the most satisfactory source of energy available to you. If you have a gasoline torch or a Bunsen burner, you can set your opening for the flame in the side of the furnace. If you intend to use an ordinary alcohol lamp or an electrical heating coil, make the opening in the base.

Many designs are possible, all based on the same construction principle. You can make a long cylindrical furnace instead of the upright type illustrated in the diagram. The diameter should suit the purpose for which the furnace is intended. The furnace can be provided with legs, if desired, or it may be designed to fit one of the rings of your ring-stand.

Make a form of cardboard or wood, or use a water glass, bowl, or flowerpot around which to shape the furnace. Set this form on a flat surface, preferably a glass plate. Grease the form and plate. Now moisten ordinary asbestos, obtained from the hardware



store, with a mixture of five parts of water and one part of sodium silicate, also called "water glass." Knead the mixture until it forms a putty-like mass. Apply this to the outside of your form until it becomes at least one inch in thickness.

While the mass is still wet, cut out the opening for your torch and smooth the edges with your fingers. Continue to slap and pack the asbestos together.

Use Nails for Legs

If your furnace is to have legs, they should be added now. Wrap the asbestos composition around nails of the proper size. You can get three of them in almost any desired length

from your hardware store. Push the nails into the form and then add enough asbestos mixture to smooth out the joint and re-enforce it.

Set aside to dry for several days. Do not hurry the drying operation by heating, for the moisture deep inside will generate steam and blow out the surface area.

When the form is dry, invert it, add a disk of waxed paper completely to cover the top and fashion a lid as illustrated. Cut a hole one inch in diameter in the lid and as far from the knob as possible to allow gasses to escape. Let the lid dry in this position for several days.

Remove the Form

The furnace is now ready for operation. Remove the form, breaking it if necessary. Heat the furnace at first to dry out any remaining moisture, then support the material to be melted in a crucible on a clay triangle for which recesses can be filed in the top of the furnace.

If an electrical heating coil is to be used in this furnace, you must use a good one. Otherwise the heat collected inside will melt the resistance wires. The plug of the coil should pass through the hole in the bottom; the socket should remain outside the furnace.

Chemical Remedy from Fungus

➤ HOPE THAT rabbit fever, or tularemia, may be successfully treated by a new chemical remedy of the same general type as penicillin appears in a report by Dr. F. R. Heilman of the Mayo Clinic.

The new substance is called streptomycin. It comes from a living organism that is halfway between a fungus and a bacteria, *Actinomyces griseus*, instead of from a mold as penicillin does. Streptomycin was discovered by Dr. Albert Schatz, Dr. Elizabeth Bugie and Prof. Selman A. Waksman of Rutgers University.

After test tube experiments showed that rabbit fever germs were very sensitive to the action of streptomycin, Dr. Heilman and associates, Miss Nellie Greenburg, Miss Mary Knutson and Miss Beatrice Bennett, gave it to mice that had killing doses of rabbit fever germs in their bodies. Of 30 untreated mice, all died of rabbit fever within 96 hours after being infected. The 30 mice which got daily doses of streptomycin for 10 days all survived.

The results of this study suggest "that this drug may be useful in the treatment of tularemia (rabbit fever) in man."

Tularemia, he also points out, is a widespread disease, killing from 3 to 5 of every 100 persons it attacks. Even when it does not kill its victims, they are sick from four weeks to several months. A serum has been developed which helps in some cases, but the serum itself has caused illness in as many as half the patients. Neither penicillin nor sulfa drugs has been effective as a remedy.

The chemical industry in Mexico is partly under government control and partly under private control; government participation developed to meet war needs.

Authoritative Survey of Tasks of Chemists and Chemical Engineers

The Work of the Chemical Profession

Reprinted from a pamphlet of the American Chemical Society

THE FIRST PART *of the A.C.S. pamphlet on vocational guidance appeared in* CHEMISTRY *for February. This article covers the tasks and types of work that chemists and chemical engineers are called upon to do. In* CHEMISTRY *for April, the portion of the report covering training will appear.*

➤ THE VARIOUS TYPES of work done by chemists and chemical engineers may be broadly classified as follows: industry, government, endowed institutions, and teaching.

The American Chemical Society in coöperation with the Bureau of Labor Statistics of the United States Department of Labor has conducted two extensive surveys of the economic status of its members.. Both surveys also give some indications of the types of employment, occupational status, and fields of specialization. The most recent survey is based on returns made early in 1944 by about 23,000 members and represents a response from about 70 per cent of those to whom blanks were sent. Of this number slightly less than 72 per cent indicate chemistry as their major field and a little more than 22 per cent are listed as chemical engineers. Most of the remainder are in fields closely related to chemistry.

Based on the total response to the 1944 survey, 17 per cent were in public employment. Those employed by private firms represented 68 per cent of all included in the survey.

An analysis of those employed by private firms showed over 95 per cent engaged in manufacturing. Following are a few of the leading fields.

	Individuals per 1000 employed by private firms
Chemical Industries	439
Petroleum and Coal Products	143
Rubber Products	77
Food Products	74
Metal Industries	59
Paper and Pulp	25
Textiles	15
Stone, Clay, and Glass	15

In industry the chemist and chemical engineer are engaged in many different types of activity, all essential to its operation. The larger number of these are associated with the production department of a given organization. Many industries not primarily chemical employ chemists and chemical engineers to control the quality of the things they purchase and sell and to introduce chemical rather than mechanical operations wherever desirable. There has been an increased trend toward the employment of chemists and chemical engineers in what may broadly be called non-technical work, and the numbers going into these fields

are so great that such opportunities should be considered by those planning a chemical career.

Research and Development

Every industry, including the chemical industry, must maintain a research and development organization if it is to succeed financially and expand. Here the chemist and the chemical engineer are engaged in improving production methods, reducing costs, developing new uses for products, and searching for new products. Many corporations require hundreds of chemists and chemical engineers to staff their research and development departments and the future of a company employing a chemical process may depend in a large measure upon their success.

In the chemical as well as in other industries, it is important—indeed necessary—for many persons to coöperate in producing a new material and manufacturing it for the market. While inventive genius in the individual is of value and needful in the development of products, it is more unusual than formerly for an individual chemist to discover a new process and obtain fame and fortune by building his discovery single-handed into a great business. Inventions more often spring from joint effort and coördinated endeavor. The chemist who had the original idea, the laboratory group which helped to develop it, the chemical engineer who designed the plant to make the products, and the organization which risked its capital in financing and launching the product—all have contributed an important share to the final result.

From the laboratory a process going to the semi-works or development stage involves larger quantities than were employed up to that point and new factors appear. When a new product, first developed in the laboratory and then made in the semi-works or pilot plant, is considered worthy of exploitation for the market, the design and construction of suitable equipment for full plant-scale production become a problem for the chemical engineer. However, in both research and development, the chemist and the chemical engineer often are associated. The chemist deals primarily with the fundamental chemistry of the new process, while the chemical engineer gives his first attention to the handling of materials, the flow of heat, and such unit operations as grinding, size separation, filtering, evaporation, distillation, and drying. It is not uncommon, however, to find the chemical engineer interested in the fundamental chemistry involved, for that gives him a better grasp of the engineering problems. In some instances the man who has developed the process in the laboratory continues with it into the plant, acting in an advisory capacity even where he does not share responsibility for operation with the chemical engineer.

It is obvious, therefore, that the research chemist and the chemical engineer often work together in development, each supplementing the specialty of the other. On the basis of their joint experience the new plant may be designed and operated or improvements made in existing processes.

Production

A process that is in full production requires both supervision and analytical control. Chemists who supervise a process are usually responsible for the

purity of the starting materials and of the products formed, for the maintenance of correct operating conditions, and for controls and measurement of combining proportions, yields, temperature, and pressure. The various functions of the plant are largely in charge of chemists or chemical engineers who understand the construction and operation of machinery and equipment. The selection of raw materials, control of chemical change in the process, and final evaluation of the finished product require analysis and testing in the laboratory. The development and standardization of methods of analyses are based on a high grade of research. Some analytical work requires not only skilled technique but continual application of fundamental theories and principles and the constant exercise of chemical judgment and discretion. Some routine tests are conducted by chemists serving their apprenticeship in the laboratory in order to learn about plant processes and products. A large proportion of routine control work has been so mechanically standardized that it may be done by technicians, not chemists, having no more than high school training. It is seldom if ever that a person in such work acquires therefrom the breadth of knowledge to advance to truly chemical work unless formal academic training is taken.

Technical Service and Sales

Many men trained as chemists and chemical engineers enter sales divisions, where opportunities have increased markedly in recent years. Members of sales organizations not only must have sound fundamental training but several years of experience in research or production. Direct selling is done by men who are gifted in meeting and dealing with business men. Technical service involves the study of a customer's problems and advice as to the best use of the company's products or equipment in the customer's plant.

To be a success a product must have economic possibilities, in short it must be sold at a profit. Thus it is necessary to have a capable marketing organization to develop and hold sales outlets. More and more leading chemical manufacturing concerns are utilizing the services of technically-trained individuals in their merchandising departments. In many large concerns market development departments are maintained separate from but actually coöperating with the sales departments.

Most companies also find it desirable to develop statistical and cost accounting units and quite often individuals with technical background are employed in such activities.

In recent years chemical companies have largely revised the type of advertising approach employed, especially in technical journals, giving greater attention to technical data and eliminating bombastic claims of size and quality. Increasing use of technically-trained individuals in advertising departments, advertising agencies serving chemical companies, concerns manufacturing equipment, and in chemical operations has been noted.

Purchasing

Men trained in chemistry and chemical engineering find opportunities in the purchasing department where they can apply to specifications and similar standards of quality their intimate knowledge of the properties of materials.

Patent Attorneys

The training given the chemist and the chemical engineer is highly important to the patent attorney. Nearly one fourth of all patents issued relate to chemistry or chemical products, and this proportion is increasing. To handle such applications properly it is essential that a patent attorney have chemical training, preferably in chemical engineering. Such training, together with knowledge of the necessary law, will qualify a person to take the Civil Service examination for entrance into the U. S. Patent Office as an examiner.

Writing and Library Work

Although the opportunities for employment are not great, technically-trained individuals have found attractive work in the fields of editing, technical writing, and reporting.

In recent years many chemical companies have found it necessary to employ individuals to do literature research work, who are trained both in chemistry and in library science. This field has been especially attractive to women with thorough technical training.

Administrators

Experience has shown that the training received by chemists and chemical engineers serves them well in administrative positions which they may attain as they develop and prove their abilities. Production men have excellent opportunities to become superintendents and managers and often technically-trained individuals rise to purely executive positions. This tendency has increased rapidly in the past decade or so and it is confidently expected to grow still more rapidly. Industries reward those who can supervise and direct the work of others, accept responsibility, and by wise decisions give evidence of sound judgment.

Consultants

Consultants comprise a small though very important percentage of the chemical profession. After having acquired experience and prestige in a special field of chemistry, it is possible for the chemist or the chemical engineer to practice successfully as a consultant. Well-recognized ability, some capital, and a thorough knowledge of the specialty, together with a broad general understanding of chemistry and chemical economics, are necessary. A few consultants have built up organizations to include a number of specialists. In recent years many consulting concerns have developed complete services contracting to design and construct entire plants. Such firms require chemists and particularly chemical engineers. Many members of chemistry and chemical engineering college and university faculties are part-time consultants.

Equipment

Large numbers of chemists and chemical engineers are employed by the manufacturers of equipment, scientific apparatus, and control devices, both for development work and for sales and service.

Government Service

A large number of people trained in chemistry and chemical engineering are engaged in work for the federal, state, or municipal governments. The greatest number are found in federal service where they are engaged in re-

search, control, and inspection. The various bureaus of the Department of Agriculture, the National Bureau of Standards, the Bureau of Mines, the Army and Navy, the Food and Drug Administration, the National Institute of Health, and the Tennessee Valley Authority maintain large technical staffs that are outstanding. Large numbers of chemists and chemical engineers are employed in the four Regional Research Laboratories of the United States Department of Agriculture as a part of the Bureau of Agricultural and Industrial Chemistry. Positions in these bureaus are under competitive Civil Service examinations, and this is also true of a few state and municipal agencies. During World War II many chemists and chemical engineers were called into special war service. A limited number utilized their chemical training as members of the Armed Forces in the Chemical Warfare Service, Ordnance, the Sanitary Corps, and various research and testing laboratories of the Army and Navy, but the larger number were employed in a civilian capacity by such war agencies as the War Production Board, the Rubber Director's Office, and the Office of Scientific Research and Development. The work of many states is growing in importance with increased demand for trained men, and the larger municipalities maintain several laboratories.

Institutional Service

Privately endowed institutions and foundations are typified by the Mellon Institute of Industrial Research, the Battelle Memorial Institute, the Armour Research Foundation, the Rockefeller Institute for Medical Research, and the Boyce Thompson Institute for Plant Research, where many trained chemists and chemical engineers work on a wide variety of problems.

Teaching

Not more than 10 per cent of all chemists are engaged in teaching. This group represents a large number of leaders in the advancement of chemical knowledge, and the chemical industry depends on this group, not only to train their technical personnel, but also to carry on much of the fundamental research. The field is very extensive for, apart from industrial dependence upon it, many allied professions demand fundamental and basic training in chemistry. This is true of medicine, dentistry, all fields of engineering, pharmacy, home economics, nursing, physiology, bacteriology, pathology, botany, veterinary medicine, forestry, certain types of library work, and many others.

The use of chemistry in so many fields gives it an important place in the curriculum of liberal arts colleges, universities, and engineering schools. Many high schools offer a one- or two-year chemistry program, although chemistry teachers often are called upon to teach other subjects as well. The greater opportunities are in college and university teaching. Institutions where research is given adequate financial support, creating opportunities for initiative and original thought offer particularly attractive opportunities. It is well recognized that the research laboratories of the universities, just as those of industry, continually discover new facts, methods, and products of chemistry. A laboratory curi-

osity of today may be an important commercial product tomorrow.

Initial appointment to a college or university faculty is usually as an instructor, who does a certain amount of teaching and laboratory demonstration. With increased responsibilities and demonstrated ability over a span of years, the instructor may be promoted to assistant professor, later to associate professor, and finally to full professor. This field offers opportunities to both men and women. Many teachers take up administrative work and advance to executive positions.

Women Chemists

There are many opportunities for women in the chemical profession. Teaching in college or high school is a recognized field. Various scientific bureaus of the federal, state, and municipal governments employ a number of women chemists. In the medical field many women are employed in hospitals as analysts, technicians, and research assistants. A few become expert in medical research and make this their life work. Large research laboratories employ women as technical librarians, indexers, and patent assistants. Secretarial and editorial work also afford important opportunities for chemically trained women. Home economics offers employment to women trained in chemical fundamentals. All these opportunities are increasing and the work is interesting to the chemist and valuable to the employing organization.

There are many positions in chemical industry which women can fill only with difficulty. Until recently almost the only industrial work open to them was as analysts. However, under the stress of war and with the shortage of men with chemical training, the fields in which women were permitted to work expanded greatly. Installation of devices eliminating to a great extent the need of considerable muscular strength made it easier for women to operate large-scale chemical equipment. The choice of an individual for a given position is now more a matter of ability than of sex.

Personal Qualifications

The student planning to enter the chemical profession should possess an inquiring mind. Chemistry is a precise science and the most meticulous accuracy is necessary to accomplish dependable results. Mental alertness is particularly needed to note minor difficulties in operating practice and thereby forestall major troubles, as well as to observe variations in experiments, since these may be important and open new lines for investigation. This is of great importance in the control of plant processes. The ability to use data prepared by others and to develop original ideas is of much value. Willingness to accept responsibility and to initiate new ideas, and an inherent desire to coöperate with others are desirable attributes. A steadiness of purpose and absolute honesty of observation, thought, and judgment are fundamental qualifications.

Employment

Unlike members of the medical, dental, and legal professions, most chemists and chemical engineers are employees. During periods of depression there has been some overcrowding in the chemical professions, but at no time in the nineteen-thirties were there as many as 10 per cent of chem-

ists and chemical engineers out of work for any length of time. It should be emphasized that steady employment is afforded to only the best qualified who achieve excellence by diligent preparation. Unemployment is found generally among those inadequately trained who are nautrally in the lower salary levels.

Most jobs, apart from those under Civil Service, are secured through personal contacts or recommendations. The larger companies send representatives to the major colleges and universities to interview those who expect to complete their courses of training within three or four months. Most educational institutions maintain placement bureaus. The classified advertising sections of technical and trade journals carry notices of positions that are vacant and can be used by those seeking positions. The American Chemical Society maintains an Employment Clearing House for its members at the national meetings. State and national government agencies are concerned with matters of employment. Personal correspondence still remains an effective and general method of locating employment.

Salaries

A beginning salary of $1800 to $2400 is paid qualified men. A few who hold a bachelor of science degree may begin in plants on an hourly basis and get less at the start. Those having graduate training are better paid. Very few doctor of philosophy or doctor of science graduates enter industry at less than $2800 per year and may get as much as $3600. In times of great shortage of manpower the starting figures of recent graduates are somewhat higher than these figures, while in periods of depression they are lower. Earning power with increased experience depends upon the ability of the individual and the degree of responsibility attained. The most recent survey of the members of the American Chemical Society completed early in 1944 indicated that 50 per cent of those who started work in 1943 received a salary above $2000 per year and 10 per cent started above $2600. The annual income including salaries and bonuses received by 10 per cent of the members with forty years of experience was in excess of $17,000 while another 10 per cent has never exceeded $3200 per year.

Non-technical or business administration positions often represent the highest paid type of work in chemical industry, the salary depending largely on the responsibility assumed. At the bottom of the salary scale are those doing strictly routine testing and analysis.

Appointment to a college teaching position is preferably given to one holding the doctor's degree. Instructorships are generally considered as apprenticeships. From $1800 to $2500 is a fair beginning salary in a college teaching position. Experienced college teachers after about ten years' service earn about $3000 to $5000, and those who pass through all grades of promotion are paid between $4000 and $10,000 per year. In small institutions the salary is generally somewhat less, but the exceptional research professor in a large college is paid somewhat more. The scale of salaries for academic work is lower than in industry.

High school teaching, with some

positions open to those with the bachelor's degree, has a beginning salary of $1200 to $1500 per year, which in mature life may increase to about $3500.

A few consultants have built up large practices through the years that earn considerable income.

The fields of chemistry and chemical engineering are not places to make large sums of money, and those primarily interested in this phase of life should seek other and more lucrative vocations. The chemist and the chemical engineer have a definite professional status and, like the doctor, dentist, and lawyer, are imbued with the idea of serving their fellow men.

Pre-cut doors, sash, moldings and other items of wood going into construction are sometimes treated with a new water-repellant sealer so that they will not change their dimensions during shipping which often happens with changing humidity.

Pop—"Funny Money," by J. Millar Watt. Reproduced by special permission of The Bell Syndicate, Inc.

Smoke May Bring On Asthma

Even Though Cause is Feathers

➤ WHEN THE patient says the spell of extremely cold weather has caused him to have an attack of asthma, he is right but so is the allergy specialist who says it is not the cold but feathers that are the cause of his asthma, as shown by scientific tests.

Feathers in such a case are the primary cause but cold weather may be a secondary or predisposing factor, Dr. Samuel M. Feinberg, of Chicago, explained in a report at the Seventh Annual Forum on Allergy in Pittsburgh.

The secondary factors which may aggravate or bring on allergic symptoms "are usually given too much importance by the public and general medical profession and too little importance by allergists," Dr. Feinberg declared.

"Their proper role should be appreciated because frequently the specific cause of the allergy cannot be found and then only the secondary cause can be managed," he said. "Even when the primary cause is known, benefit can be derived from the attention given to the predisposing causes."

Some of the common secondary factors, he said, are chemical, mechanical, thermal, nervous and mental, weather and climate and infections.

A common cold, for example, will make the allergic nose more troublesome. So will the mechanical action of chalk dust which school teachers with nasal allergy usually think is the cause of their allergy.

Inhaling soft coal smoke, gasoline fumes, paint odors and the like may be a chemical factor that brings on an attack of asthma though the primary cause is a food or pollen.

Emotional upsets, excitement, worry and similar nervous disturbances may precipitate or aggravate allergic symptoms, though in Dr. Feinberg's opinion it is doubtful whether such nervous factors by themselves are able to cause diseases such as asthma, hives or eczema.

Answers to Chem Quiz on Page 15

a. Iridium, from Latin *Iris,* the Goddess of the Rainbow.

b. Iodine, from Greek *iodes,* violet.

c. Cesium, from Latin *caesius,* sky blue; Indium, from *indigo.*

d. Chlorine, from Greek *chloros,* green; Praseodymium, from Greek *prasios,* green; Thallium, from Greek *thallos,* green twig.

e. Zirconium, from Arabic *zargun,* color of gold.

f. Rhodium, from Greek *rhodon,* rose; Rubidium, from Latin *rubidus,* red.

Ammonia, used in enormous quantities in artificial ice plants and to provide refrigeration in many industrial processes, is called an irreplaceable chemical in the manufacture of sulfuric acid, alcohol, soda ash and caustic soda.

Primitive Methods for Noble Metals

➤ COPPER is refined by "poling" the melted metal with a stick of green wood. Silver is freed of lead by "cupellation," melting it in a crucible made of ground bones—any old bones you happen to "find in the street." These processes are stamped as ancient by the very materials they use. But they work. "Amalgamation" is a much more sophisticated procedure, but it too has been in use a long time. These primitive metallurgical methods are characteristic of man's oldest metals.

Until the introduction of electrolytic separation, little change had been made in metal-working procedures since pre-historic times. The processes described by Agricola in the sixteenth century were very likely only a refinement of methods puzzled out by metal-working priests of Egypt, or other sons of Tubal-Cain.

Herbert Hoover's notes, reprinted here, as in the original, in smaller type, are the authoritative summaries of all that can be gleaned about earlier metallurgical processes from writers of antiquity.

GEORGIUS AGRICOLA DE RE METALLICA translated from the first Latin edition of 1556 with biographical introduction, annotations and appendices upon the development of mining methods, metallurgical processes, geology, mineralogy and mining law from the earliest times to the 16th century by Herbert Clark Hoover and Lou Henry Hoover. Published for the translators by the Mining Magazine, Salisbury House, London, E.C. 1912.

Poling of Copper

➤ THE NATURE of copper is such that when it is "dried" it becomes ash coloured, and since this copper contains silver, it is smelted again in the blast furnaces.

I have described sufficiently the method by which exhausted liquation cakes are "dried"; now I will speak of the method by which they are made into copper after they have been "dried." These cakes, in order that they may recover the appearance of copper which they have to some extent lost, are melted in four furnaces, which are placed against the second long wall in the part of the building between the second and third transverse walls. This space is sixty-three feet and two palms long, and since each of these furnaces occupies thirteen feet, the space which is on the right side of the first furnace, and on the left of the fourth, are each three feet and three palms wide, and the distance between the second and third furnace is six feet. In the middle of each of these three spaces is a door, a foot and a half wide and six feet high, and the middle one is common

to the master of each of the furnaces. Each furnace has its own chimney, which rises between the two long walls mentioned above, and is supported by two arches and a partition wall. The partition wall is between the two furnaces, and is five feet long, ten feet high, and two feet thick; in front of it is a pillar belonging in common to the front arches of the furnace on either side, which is two feet and as many palms thick, three feet and a half wide. The front arch reaches from this common pillar to another pillar that is common to the side arch of the same furnace; this arch on the right spans from the second long wall to the same pillar, which is two feet and as many palms wide and thick at the bottom. The interior of the front arch is nine feet and a palm wide, and eight feet high at its highest point; the interior of the arch which is on the right side, is five feet and a palm wide, and of equal height to the other, and both the arches are built of the same height as the partition wall. Imposed upon these arches and the partition wall are the walls of the chimney; these slope upward, and thus contract, so that at the upper part, where the fumes are emitted, the opening is eight feet in length, one foot and three palms in width. The fourth wall of the chimney is built vertically upon the second long wall. As the partition wall is common to the two furnaces, so its superstructure is common to the two chimneys. In this sensible manner the chimney is built. At the front each furnace is six feet two palms long, and three feet two palms wide, and a cubit high; the back of each furnace is against the second long wall, the front being open. The first furnace is open and sloping at the right side, so that the slags may be drawn out; the left side is against the partition wall, and has a little wall built of bricks cemented together with lute; this little wall protects the partition wall from injury by the fire. On the contrary; the second furnace has the left side open and the right side is against the partition wall, where also it has its own little wall which protects the partition from the fire. The front of each furnace is built of rectangular rocks; the interior of it is filled up with earth. Then in each of the furnaces at the rear, against the second long wall, is an aperture through an arch at the back, and in these are fixed the copper pipes. Each furnace has a round pit, two feet and as many palms wide, built three feet away from the partition wall. Finally, under the pit of the furnace, at a depth of a cubit, is the hidden receptacle for moisture, similar to the others, whose vent penetrates through the second long wall and slopes upward to the right from the furnace, and to the left from the second. If copper is to be made the next day, then the master cuts out the crucible with a spatula, the blade of which is three digits wide and as many palms long, the iron handle being two feet long and one and a half digits in diameter; the wooden handle inserted into it is round, five feet long and two digits in diameter. Then, with another cutting spatula, he makes the crucible smooth; the blade of this spatula is a palm wide and two palms long; its handle, partly of iron, partly of wood, is similar in every respect to the first one. Afterward he throws pulverized clay and charcoal into the crucible, pours water over it, and sweeps it over with a broom into which a stick is fixed. Then imme-

A—Hearth of the furnace. B—Chimney. C—Common pillar. D—Other pillars. The partition wall is behind the common pillar and not to be seen. E—Arches. F—Little walls which protect the partition wall from injury by the fire. G—Crucibles. H—Second long wall. I—Door. K—Spatula. L—The other spatula. M—The broom in which is inserted a stick. N—Pestles. O—Wooden mallet. P—Plate. Q—Stones. R—Iron rod.

diately he throws into the crucible a powder, made of two wheelbarrowsful of sifted charcoal dust, as many wheelbarrowsful of pulverized clay likewise sifted, and six basketsful of river sand which has passed through a very fine sieve. This powder, like that used by smelters, is sprinkled with water and moistened before it is put into the crucible, so that it may be fashioned by the hands into shapes similar to snowballs. When it has been put in, the master first kneads it and makes it smooth with his hands, and then pounds it with two wooden pestles, each of which is a cubit long; each pestle has a round head at each end, but one of these is a palm in diameter,

the other three digits; both are thinner in the middle, so that they may be held in the hand. Then he again throws moistened powder into the crucible, and again makes it smooth with his hands, and kneads it with his fists and with the pestles; then, pushing upward and pressing with his fingers, he makes the edge of the crucible smooth. After the crucible has been made smooth, he sprinkles in dry charcoal dust, and again pounds it with the same pestles, at first with the narrow heads, and afterward with the wider ones. Then he pounds the crucible with a wooden mallet two feet long, both heads of which are round and three digits in diameter; its wooden handle is two palms long, and one and a half digits in diameter. Finally he throws into the crucible as much pure sifted ashes as both hands can hold, and pours water into it, and, taking an old linen rag, he smears the crucible over with the wet ashes. The crucible is round and sloping. If copper is to be made from the best quality of "dried" cakes, it is made two feet wide and one deep, but if from other cakes, it is made a cubit wide and two palms deep. The master also has an iron band curved at both ends, two palms long and as many digits wide, and with this he cuts off the edges of the crucible if they are higher than is necessary. The copper pipe is inclined, and projects three digits from the wall, and has its upper end and both sides smeared thick with lute, that it may not be burned; but the underside of the pipe is smeared thinly with lute, for this side reaches almost to the edge of the crucible, and when the crucible is full the molten copper touches it. The wall above the pipe is smeared over with lute, lest that should be damaged. He does the same to the other side of an iron plate, which is a foot and three palms long and a foot high; this stands on stones near the crucible at the side where the hearth slopes, in order that the slag may run out under it. Others do not place the plates upon stones, but cut out of the plate underneath a small piece, three digits long and three digits wide; lest the plate should fall, it is supported by an iron rod fixed in the wall at a height of two palms and the same number of digits, and it projects from the wall three palms.

Then with an iron shovel, whose handle is six feet long, he throws live charcoal into the crucible; or else charcoal, kindled by means of a few live coals, is added to them. Over the live charcoal he lays "dried" cakes, which, if they were of copper of the first quality, weigh all together three *centumpondia,* or three and a half *centumpondia*; but if they were of copper of the second quality, then two and a half *centumpondia*; if they were of the third quality, then two *centumpondia* only; but if they were of copper of very superior quality, then they place upon it six *centumpondia*, and in this case they make the crucible wider and deeper. The lowest "dried" cake is placed at a distance of two palms from the pipe, the rest at a greater distance, and when the lower ones are melted the upper ones fall down and get nearer to the pipe; if they do not fall down they must be pushed with a shovel. The blade of the shovel is a foot long, three palms and two digits wide, the iron part of the handle is two palms long, the wooden part nine feet. Round about the "dried" cakes are placed large long pieces of charcoal, and in

the pipe are placed medium-sized pieces. When all these things have been arranged in this manner, the fire must be more violently excited by the blast from the bellows. When the copper is melting and the coals blaze, the master pushes an iron bar into the middle of them in order that they may receive the air, and that the flame can force its way out. This pointed bar is two and a half feet long, and its wooden handle four feet long. When the cakes are partly melted, the master, passing out through the door, inspects the crucible through the bronze pipe, and if he should find too much of the "slag" is adhering to the mouth of the pipe, and thus impeding the blast of the bellows, he inserts the hooked iron bar into the pipe through the nozzle of the bellows, and, turning this about the mouth of the pipe, he removes the "slags" from it. The hook on this bar is two digits high; the iron part of the handle is three feet long; the wooden part is the same number of palms long. Now it is time to insert the bar under the iron plate, in order that the "slags" may flow out. When the cakes, being all melted, have run into the crucible, he takes out a sample of copper with the third round bar, which is made wholly of iron, and is three feet long, a digit thick, and has a steel point lest its pores should absorb the copper. When he has compressed the bellows, he introduces this bar as quickly as possible into the crucible through the pipe between the two nozzles, and takes out samples two, three, or four times, until he finds that the copper is perfectly refined. If the copper is good it adheres easily to the bar, and two samples suffice; if it is not good, then many are required. It is necessary to smelt it in the crucible until the copper adhering to the bar is seen to be of a brassy colour, and if the upper as well as the lower part of the thin layer of copper may be easily broken, it signifies that the copper is perfectly melted; he places the point of the bar on a small iron anvil, and chips off the thin layer of copper from it with a hammer.

If the copper is not good, the master draws off the "slags" twice, or three times if necessary—the first time when some of the cakes have been melted, the second when all have been melted, the third time when the copper has been heated for some time. If the copper was of good quality, the "slags" are not drawn off before the operation is finished, but at the time they are to be drawn off, he depresses the bar over both bellows, and places over both a stick, a cubit long and a palm wide, half cut away at the upper part, so that it may pass under the iron pin fixed at the back in the perforated wood. This he does likewise when the copper has been completely melted. Then the assistant removes the iron plate with the tongs; these tongs are four feet three palms long, their jaws are about a foot in length, and their straight part measures two palms and three digits, and the curved a palm and a digit. The same assistant, with the iron shovel, throws and heaps up the larger pieces of charcoal into that part of the hearth which is against the little wall which protects the other wall from injury by fire, and partly extinguishes them by pouring water over them. The master, with a hazel stick inserted into the crucible, stirs it twice. Afterward he draws off the slags with a rabble, which consists of an iron blade, wide and sharp,

and of alder-wood; the blade is a digit and a half in width and three feet long; the wooden handle inserted in its hollow part is the same number of feet long, and the alder-wood in which the blade is fixed must have the figure of a rhombus; it must be three palms and a digit long, a palm and two digits wide, and a palm thick. Subsequently he takes a broom and sweeps the charcoal dust and small coal over the whole of the crucible, lest the copper should cool before it flows together; then, with a third rabble, he cuts off the slags which may adhere to the edge of the crucible. The blade of this rabble is two palms long and a palm and one digit wide, the iron part of the handle is a foot and three palms long, the wooden part six feet. Afterward he again draws off the slags from the crucible, which the assistant does not quench by pouring water upon them, as the other slags are usually quenched, but he sprinkles over them a little water and allows them to cool. If the copper should bubble, he presses down the bubbles with the rabble. Then he pours water on the wall and the pipes, that it may flow down warm into the crucible, for the copper, if cold water were to be poured over it while still hot, would spatter about. If a stone, or a piece of lute or wood, or a damp coal should then fall into it, the crucible would vomit out all the copper with a loud noise like thunder, and whatever it touches it injures and sets on fire. Subsequently he lays a curved board with a notch in it over the front part of the crucible; it is two feet long, a palm and two digits wide, and a digit thick. Then the copper in the crucible should be divided into cakes with an iron wedge-shaped bar; this is three feet long, two digits wide, and steeled on the end for the distance of two digits, and its wooden handle is three feet long. He places this bar on the notched board, and, driving it into the copper, moves it forward and back, and by this means the water flows into the vacant space in the copper, and he separates the cake from the rest of the mass. If the copper is not perfectly smelted the cakes will be too thick, and cannot be taken out of the crucible easily. Each cake is afterward seized by the assistant with the tongs and plunged into the water in the tub; the first one is placed aside so that the master may re-melt it again immediately, for, since some "slags" adhere to it, it is not as perfect as the subsequent ones; indeed, if the copper is not of good quality, he places the first two cakes aside. Then, again pouring water over the wall and the pipes, he separates out the second cake, which the assistant likewise immerses in water and places on the ground together with the others separated out in the same way, which he piles upon them. These, if the copper was of good quality, should be thirteen or more in number; if it was not of good quality, then fewer. If the copper was of good quality, this part of the operation, which indeed is distributed into four parts, is accomplished by the master in two hours; if of mediocre quality, in two and a half hours; if of bad quality, in three. The "dried" cakes are re-melted, first in the first crucible and then in the second. The assistant must, as quickly as possible, quench all the cakes with water, after they have been cut out of the second crucible. Afterward with the tongs he replaces in its proper place the iron plate

which was in front of the furnace, and throws the charcoal back into the crucible with a shovel. Meanwhile the master, continuing his work, removes the wooden stick from the bars of the bellows, so that in re-melting the other cakes he may accomplish the third part of his process; this must be carefully done, for if a particle from any iron implement should by chance fall into the crucible, or should be thrown in by any malevolent person, the copper could not be made until the iron had been consumed, and therefore double labour would have to be expended upon it. Finally, the assistant extinguishes all the glowing coals, and chips off the dry lute from the mouth of the copper pipe with a hammer; one end of this hammer is pointed, the other round, and it has a wooden handle five feet long. Because there is danger that the copper would be scattered if the *pompholyx* and *spodos*, which adhere to the walls and the hood erected upon them, should fall into the crucible, he cleans them off in the meantime. Every week he takes the copper flowers out of the tub, after having poured off the water, for these fall into it from the cakes when they are quenched.

Note on Copper Refining

This description of refining copper in an open hearth by oxidation with a blast and "poling"—the *gaarmachen* of the Germans—is so accurate, and the process is so little changed in some parts of Saxony, that it might have been written in the 20th century instead of the 16th. The best account of the old practice in Saxony after Agricola is to be found in Schlüter's *Hütte Werken* (Braunschweig, 1738, Chap. CXVIII.). The process has largely been displaced by electrolytic methods, but is still in use in most refineries as a step in electrolytic work. It may be unnecessary to repeat that the process is one of subjecting the molten mass of impure metal to a strong and continuous blast, and as a result, not only are the impurities to a considerable extent directly oxidized and taken off as a slag, but also a considerable amount of copper is turned into cuprous oxide. This cuprous oxide mostly melts and diffuses through the metallic copper, and readily parting with its oxygen to the impurities further facilitates their complete oxidation. The blast is continued until the impurities are practically eliminated, and at this stage the molten metal contains a great deal of dissolved cuprous oxide, which must be reduced. This is done by introducing a billet of green wood ("poling"), the dry distillation of which generates large quantities of gases, which reduce the oxide. The state of the metal is even today in some localities tested by dipping into it the point of an iron rod; if it be at the proper state the adhering copper has a net-like appearance, should be easily loosened from the rod by dipping in water, is of a reddish-copper colour and should be quite pliable; if the metal is not yet refined, the sample is thick, smooth, and detachable with difficulty; if over-refined, it is thick and brittle. By allowing water to run on to the surface of the molten metal, thin cakes are successively formed and taken off. These cakes were the article known to commerce over several centuries as "rosetta copper."

The first few cakes are discarded as containing impurities or slag, and if the metal be of good quality the cakes are thin and of a red colour. Their colour and thinness, therefore, become a criterion of purity. The cover of charcoal or charcoal dust maintained upon the surface of the metal tended to retard oxidation, but prevented volatilization and helped to secure the impurities as a slag instead. Karsten (*Archiv.*, 1st series, p. 46) gives several analyses of the slag from refining "dried" copper, showing it to contain from 51.7 to 67.4 per cent lead oxide, 6.2 to 19.2 per cent cuprous oxide, and 21.4 to 23.9 silica (from the furnace bottoms), with minor quantities of iron, antimony, etc. The "bubbles" referred to by Agricola were apparently the shower of copper globules which takes place upon the evolution of sulphur dioxide, due to the reaction of the cuprous oxide upon any remaining sulphide of copper when the mass begins to cool.

Historical Note on Copper Refining

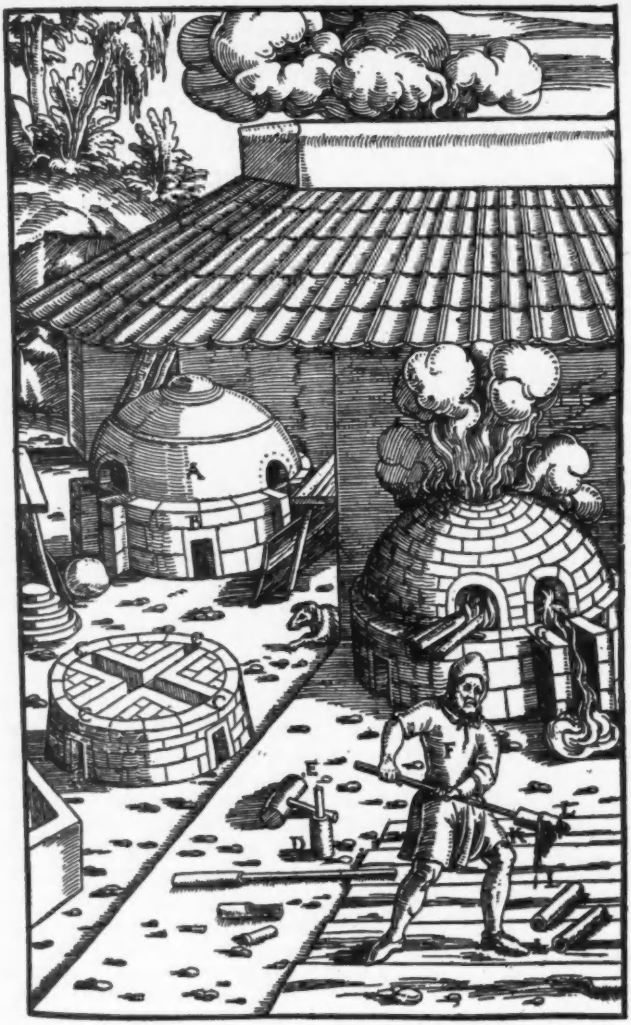
It is impossible to say how the Ancients refined copper, beyond the fact that they often re-smelted it. Such notes as we can find are set out in the note on copper smelting. The first authentic reference to poling is in Theophilus (1150 to 1200 A.D., Hendrie's translation, p. 313), which shows a very good understanding of this method of refining copper: "Of the Purification of Copper. Take an iron dish of the size you wish, and line it inside and out with clay strongly beaten and mixed, and it is carefully dried. Then place it before a forge upon the coals, so that when the bellows act upon it the wind may issue partly within and partly above it, and not below it. And very small coals being placed round it, place the copper in it equally, and add over it a heap of coals. When by blowing a long time this has become melted, uncover it and cast immediately fine ashes of coals over it, and stir it with a thin and dry piece of wood as if mixing it, and you will directly see the burnt lead adhere to these ashes like a glue, which being cast out again superpose coals, and blowing for a long time, as at first, again uncover it, and then do as you did before. You do this until at length by cooking it you can withdraw the lead entirely. Then pour it over the mould which you have prepared for this, and you will thus prove if it be pure. Hold it with the pincers, glowing as it is, before it has become cold, and strike it with a large hammer strongly over the anvil, and if it be broken or split you must liquefy it anew as before. If, however, it should remain sound, you will cool it in water, and you cook other (copper) in the same manner." Biringuccio (III, 8) in 1540 describes the process briefly, but omits the poling, an essential in the production of malleable copper.

Cupellation of Silver

▶ The artificer who undertakes the work of parting the metals, distributes the operation into two shifts of two days. On the one morning he sprinkles a little ash into the lute, and when he has poured some water over it he

brushes it over with a broom. Then he throws in sifted ashes and dampens them with water, so that they could be moulded into balls like snow. The ashes are those from which lye has been made by letting water percolate through them, for other ashes which are fatty would have to be burnt again in order to make them less fat. When he has made the ashes smooth by pressing them with his hands, he makes the crucible slope down toward the middle; then he tamps it, as I have described, with a rammer. He afterward, with two small wooden rammers, one held in each hand, forms the channel through which the litharge flows out. The heads of these small rammers are each a palm wide, two digits thick, and one foot high; the handle of each is somewhat rounded, is a digit and a half less in diameter than the rammer-head, and is three feet in length; the rammer-head as well as the handle is made of one piece of wood. Then with shoes on, he descends into the crucible and stamps it in every direction with his feet, in which manner it is packed and made sloping. Then he again tamps it with a large rammer, and removing his shoe from his right foot he draws a circle around the crucible with it, and cuts out the circle thus drawn with an iron plate. This plate is curved at both ends, is three palms long, as many digits wide, and has wooden handles a palm and two digits long, and two digits thick; the iron plate is curved back at the top and ends, which penetrate into handles. There are some who use in the place of the plate a strip of wood, like the rim of a sieve; this is three digits wide, and is cut out at both ends that it may be held in the hands. Afterward he tamps the channel through which the litharge discharges. Lest the ashes should fall out, he blocks up the aperture with a stone shaped to fit it, against which he places a board, and lest this fall, he props it with a stick. Then he pours in a basketful of ashes and tamps them with the large rammer; then again and again he pours in ashes and tamps them with the rammer. When the channel has been made, he throws dry ashes all over the crucible with a sieve, and smooths and rubs it with his hands. Then he throws three basketsful of damp ashes on the margin all round the edge of the crucible, and lets down the dome. Soon after, climbing upon the crucible, he builds up ashes all around it, lest the molten alloy should flow out. Then, having raised the lid of the dome. he throws a basketful of charcoal into the crucible, together with an iron shovelful of glowing coals, and he also throws some of the latter through the apertures in the sides of the dome, and he spreads them with the same shovel. This work and labour is finished in the space of two hours.

An iron plate is set in the ground under the channel, and upon this is placed a wooden block, three feet and a palm long, a foot and two palms and as many digits wide at the back, and two palms and as many digits wide in front; on the block of wood is placed a stone, and over it an iron plate similar to the bottom one, and upon this he puts a basketful of charcoal, and also an iron shovelful of burning charcoals. The crucible is heated in an hour, and then, with the hooked bar with which the litharge is drawn off, he stirs the remainder of the charcoal about. This hook is a palm long and



A—Chamber of the furnace. B—Its bed. C—Passages. D—Rammer. E—Mallet. F—Artificer making tubes from litharge according to the Roman method. G—Channel. H—Litharge. I—Lower crucible or hearth. K—Stick. L—Tubes.

three digits wide, has the form of a double triangle, and has an iron handle four feet long, into which is set a wooden one six feet long. There are some who use instead a simple hooked bar. After about an hour's time, he stirs the charcoal again with the bar, and with the shovel throws into the crucible the burning charcoals lying in the channel; then again, after the space of an hour, he stirs the burning charcoals with the same bar. If he did not thus stir them about, some blackness would remain in the crucible and that part would be damaged, because it would not be sufficiently dried. Therefore the assistant stirs and turns the burning charcoal that it may be entirely burnt up, and so that the crucible may be well heated, which takes three hours; then the crucible is left quiet for the remaining two hours.

When the hour of eleven has struck, he sweeps up the charcoal ashes with a broom and throws them out of the crucible. Then he climbs on to the dome, and passing his hand through its opening, and dipping an old linen rag in a bucket of water mixed with ashes, he moistens the whole of the crucible and sweeps it. In this way he uses two bucketsful of the mixture, each holding five Roman *sextarii*, and he does this lest the crucible, when the metals are being parted, should break open; after this he rubs the crucible with a doe skin, and fills in the cracks. Then he places at the left side of the channel, two fragments of hearth-lead, laid one on the top of the other, so that when partly melted they remain fixed and form an obstacle, that the litharge will not be blown about by the wind from the bellows, but remain in its place. It is expedient, however, to use a brick in the place of the hearth-lead, for as this gets much hotter, therefore it causes the litharge to form more rapidly. The crucible in its middle part is made two palms and as many digits deeper.

There are some who having thus prepared the crucible, smear it over with incense, ground to powder and dissolved in white of egg, soaking it up in a sponge and then squeezing it out again; there are others who smear over it a liquid consisting of white of egg and double the amount of bullock's blood or marrow. Some throw lime into the crucible through a sieve.

Afterward the master of the works weighs the lead with which the gold or silver or both are mixed, and he sometimes puts a hundred *centumpondia* into the crucible, but frequently only sixty, or fifty, or much less. After it has been weighed, he strews about in the crucible three small bundles of straw, lest the lead by its weight should break the surface. Then he places in the channel several cakes of lead alloy, and through the aperture at the rear of the dome he places some along the sides; then, ascending to the opening at the top of the dome, he arranges in the crucible round about the dome the cakes which his assistant hands to him, and after ascending again and passing his hands through the same aperture, he likewise places other cakes inside the crucible. On the second day those which remain he, with a fork, places on the wood through the rear aperture of the dome.

When the cakes have been thus arranged through the hole at the top of the dome, he throws in charcoal with a basket woven of wooden twigs. Then he places the lid over the dome, and

the assistant covers over the joints with lute. The master himself throws half a basketful of charcoal into the crucible through the aperture next to the nozzle pipe, and prepares the bellows, in order to be able to begin the second operation on the morning of the following day. It takes the space of one hour to carry out such a piece of work, and at twelve all is prepared. These hours all reckoned up make a sum of eight hours.

Now it is time that we should come to the second operation. In the morning the workman takes up two shovelsful of live charcoals and throws them into the crucible through the aperture next to the pipes of the nozzles; then through the same hole he lays upon them small pieces of fir-wood or of pitch pine, such as are generally used to cook fish. After this the water-gates are opened, in order that the machine may be turned which depresses the levers of the bellows. In the space of one hour the lead alloy is melted; and when this has been done, he places four sticks of wood, twelve feet long, through the hole in the back of the dome, and as many through the channel; these sticks, lest they should damage the crucible, are both weighted on the ends and supported by trestles; these trestles are made of a beam, three feet long, two palms and as many digits wide, two palms thick, and have two spreading legs at each end. Against the trestle, in front of the channel, there is placed an iron plate, lest the litharge, when it is extracted from the furnace, should splash the smelter's shoes and injure his feet and legs. With an iron shovel or a fork he places the remainder of the cakes through the aperture at the back of the dome on to the sticks of wood already mentioned.

The native silver, or silver glance, or grey silver, or ruby silver, or any other sort, when it has been flattened out, and cut up, and heated in an iron crucible, is poured into the molten lead mixed with silver, in order that impurities may be separated. As I have often said, this molten lead mixed with silver is called *stannum*. . . .

If it be difficult to separate the lead from the silver, he throws copper and charcoal dust into the molten silver-lead alloy. If the alloy of argentiferous gold and lead, or the silver-lead alloy, contains impurities from the ore, then he throws in either equal portions of argol and Venetian glass or sal-ammoniac, or of Venetian glass and of Venetian soap; or else unequal portions, that is, two of argol and one of iron rust; there are some who mix a little saltpetre with each compound. To one *centumpondium* of the alloy is added a *bes* or a *libra* and a third of the powder, according to whether it is more or less impure. The powder certainly separates the impurities from the alloy. Then, with a kind of rabble he draws out through the channel, mixed with charcoal, the scum, as one might say, of the lead; the lead makes this scum when it becomes hot, but that less of it may be made it must be stirred frequently with the bar.

Within the space of a quarter of an hour the crucible absorbs the lead; at the time when it penetrates into the crucible it leaps and bubbles. Then the master takes out a litle lead with an iron ladle, which he assays, in order to find what proportion of silver there is in the whole of the alloy; . . .

Now when the colour begins to show in the silver, bright spots appear, some of them being almost white, and a moment afterward it becomes absolutely white. Then the assistant lets down the water-gates, so that, the race being closed, the water-wheel ceases to turn and the bellows are still. Then the master pours several buckets of water on the silver to cool it; others pour beer over it to make it whiter, but this is of no importance since the silver has yet to be refined. Afterward, the cake of silver is raised with the pointed iron bar, which is three feet long and two digits wide, and has a wooden handle four feet long fixed in its socket. When the cake of silver has been taken from the crucible, it is laid upon a stone, and from part of it the hearth-lead, and from the other part the litharge, is chipped away with a hammer; then it is cleansed with a bundle of brass wire dipped in water. When the lead is separated from the silver, more silver is frequently found than when it was assayed; for instance, if before there were three *unciae* and as many *drachmae* in a *centumpondium*, they now sometimes find three *unciae* and a half. Often the hearth-lead remaining in the crucible is a palm deep; it is taken out with the rest of the ashes and is sifted, and that which remains in the sieve, since it is hearth-lead, is added to the hearth-lead.

The ashes which pass through the sieve are of the same use as they were at first, for, indeed, from these and pulverised bones they make the cupels.

Historical Note on Cupellation

The cupellation process is of great antiquity, and the separation of silver from lead in this manner very probably antedates the separation of gold and silver. We can be certain that the process has been used continuously for at least 2,300 years, and was only supplanted in part by Pattinson's crystallization process in 1833, and further invaded by Parks' zinc method in 1850, and during the last fifteen years further supplanted in some works by electrolytic methods. However, it yet survives as an important process. It seems to us that there is no explanation possible of the recovery of the large amounts of silver possessed from the earliest times, without assuming reduction of that metal with lead, and this necessitates cupellation. If this be the case, then cupellation was practiced in 2500 B.C. . . .

The works of either Theophilus (1150-1200 A.D.) or Geber (prior to the 14th century) are the first where adequate description of the cupel itself can be found. The uncertainty of dates renders it difficult to say which is earliest. Theophilus (Hendrie's translation, p. 317) says: "How gold is separated from copper: But if at any time you have broken copper or silver-gilt vessels, or any other work, you can in this manner separate the gold. Take the bones of whatever animal you please, which (bones) you may have found in the street, and burn them, being cold, grind them finely, and mix with them a third part of beechwood ashes, and make cups as we have mentioned above in the purification of silver; you will dry these at the fire or in the sun. Then you carefully scrape the gold from the copper, and you will fold this

scraping in lead beaten thin, and one of these cups being placed in the embers before the furnace, and now become warm, you place in this fold of lead with the scraping, and coals being heaped upon it you will blow it. And when it has become melted, in the same manner as silver is accustomed to be purified, sometimes by removing the embers and by adding lead, sometimes by re-cooking and warily blowing, you burn it until, the copper being entirely absorbed the gold may appear pure."

We quote Geber from the Nuremberg edition of 1545, p. 152: "Now we describe the method of this. Take sifted ashes or *calx*, or the powder of the burned bones of animals, or all of them mixed, or some of them; moisten with water, and press it with your hand to make the mixture firm and solid, and in the middle of this bed make a round solid crucible and sprinkle a quantity of crushed glass. Then permit it to dry. When it is dry, place into the crucible that which we have mentioned which you intend to test. On it kindle a strong fire, and blow upon the surface of the body that is being tested until it melts, which, when melted, piece after piece of lead is thrown upon it, and blow over it a strong flame. When you see it agitated and moved with strong shaking motion it is not pure. Then wait until all of the lead is exhaled. If it vanishes and does not cease its motion it is not purified. Then again throw lead and blow again until the lead separates. If it does not become quiet again, throw in lead and blow on it until it is quiet and you see it bright and clear on the surface."

Cupellation is mentioned by most of the alchemists, but as a metallurgical operation on a large scale the first description is by Biringuccio in 1540.

Amalgamation of Gold

➤ SOME PEOPLE build a machine which at one and the same time can crush, grind, cleanse, and wash the gold-ore, and mix the gold with quicksilver. This machine has one water-wheel, which is turned by a stream striking its buckets; the main axle on one side of the water-wheel has long cams, which raise the stamps that crush the dry ore. Then the crushed ore is thrown into the hopper of the upper millstone, and gradually falling through the opening, is ground to powder. The lower millstone is square, but has a round depression in which the round, upper millstone turns, and it has an outlet from which the powder falls into the first tub. A vertical iron axle is dovetailed into a cross-piece, which is in turn fixed into the upper millstone; the upper pinion of this axle is held in a bearing fixed in a beam; the drum of the vertical axle is made of rundles, and is turned by the toothed drum on the main axle, and thus turns the millstone. The powder falls continually into the first tub, together with water, and from there runs into a second tub which is set lower down, and out of the second into a third, which is the lowest; from the third, it generally flows into a small trough hewn out of a tree trunk. Quicksilver is placed in each tub, across which is fixed a small plank, and through a hole in the middle of each plank there passes a small upright axle, which is enlarged above

A—Water-wheel. B—Axle. C—Stamp. D—Hopper in the upper millstone. E—Opening passing through the centre. F—Lower millstone. G—Its round depression. H—Its outlet. I—Iron axle. K—Its crosspiece. L—Beam. M—Drum of rundles on the iron axle. N—Toothed drum of main axle. O—Tubs. P—The small planks. Q—Small upright axles. R—Enlarged part of one. S—Their paddles. T—Their drums which are made of rundles. V—Small horizontal axle set into the end of the main axle. X—Its toothed drums. Y—Three sluices. Z—Their small axles. AA—Spokes. BB—Paddles.

the plank to prevent it from dropping into the tub lower than it should. At the lower end of the axle three sets of paddles intersect, each made from two little boards fixed to the axle opposite each other. The upper end of this axle has a pinion held by a bearing set in a beam, and around each of these axles is a small drum made of rundles, each of which is turned by a small toothed drum on a horizontal axle, one end of which is mortised into the large horizontal axle, and the other end is held in a hollow covered with thick iron plates in a beam. Thus the paddles, of which there are three sets in each tub, turn round, and agitating the powder, thoroughly mix it with water and separate the minute particles of gold from it, and these are attracted by the quicksilver and purified. The water carries away the waste. The quicksilver is poured into a bag made of leather or cloth woven from cotton, and when this bag is squeezed, as I have described elsewhere, the quicksilver drips through it into a jar placed underneath. The pure gold[1] remains in the bag. Some people substitute three broad sluices for the tubs, each of which has an angular axle on which are set six narrow spokes, and to them are fixed the same number of broad paddles. The water that is poured in strikes these paddles and turns them round, and they agitate the powder which is mixed with the water and separate the metal from it. If the powder which is being treated contains gold particles, the first method of washing is far superior, because the quicksilver in the tubs immediately attracts the gold; if it is powder in which are the small black stones from which tin is smelted, this latter method is not to be despised. It is very advantageous to place interlaced fir boughs in the sluices in which such tin-stuff is washed, after it has run through the launders from the mills, because the fine tin-stone is either held back by the twigs, or if the current carries them along they fall away from the water and settle down.

Historical Note on Gold

There is ample evidence of gold being used for ornamental purposes prior to any human record. The occurrence of large quantities of gold in native form, and the possibility of working it cold, did not necessitate any particular metallurgical ingenuity. The earliest indications of metallurgical work are, of course, among the Egyptians, the method of washing being figured as early as the monuments of the IV Dynasty (prior to 3800 B.C.). There are in the British Museum two stelae of the XII Dynasty (2400 B.C.) relating to officers who had to do with gold mining in Nubia, and upon one there are references to working what appears to be ore. If this be true, it is the earliest reference to this subject. The Papyrus map (1500 B.C.) of a gold mine, in the Turin Museum, probably refers to a quartz mine. Of literary evidences there is frequent mention of refining gold and passing it through the fire in the Books of Moses, arts no doubt learned from the Egyptians. As to working gold ore as distinguished from alluvial, we have nothing very tangible, unless it be the stelae

[1] This same error of assuming squeezed amalgam to be pure gold occurs in Pliny: see Historical Note on Amalgamation.

above, until the description of Egyptian gold mining by Agatharcides. This geographer, of about the 2nd century B.C., describes very clearly indeed the mining, crushing, and concentration of ore and the refining of the concentrates in crucibles with lead, salt, and barley bran. We may mention in passing that Theognis (6th century B.C.) is often quoted as mentioning the refining of gold with lead, but we do not believe that the passage in question: "But having been put to the test and being rubbed beside (or against) lead as being refined gold, you will be fair," etc.; or much the same statement again will stand much metallurgical interpretation. In any event, the myriads of metaphorical references to fining and purity of gold in the earliest shreds of literature do not carry us much further than do those of Shakespeare or Milton. Vitruvius and Pliny mention the recovery or refining of gold with mercury; and it appears to us that gold was parted from silver by cementation with salt prior to the Christian era. We first find mention of parting with sulphur in the 12th century, with nitric acid prior to the 14th century, by antimony sulphide prior to the 15th century, and by cementation with nitre by Agricola. The first mention of parting gold from copper occurs in the early 16th century. The first comprehensive description of gold metallurgy in all its branches is in *De Re Metallica*.

Historical Note on Amalgamation

The recovery of gold by the use of mercury possibly dates from Roman times, but the application of the process to silver does not seem to go back prior to the 16th century. Quicksilver was well known to the Greeks, and is described by Theophrastus and others. However, the Greeks made no mention of its use for amalgamation, and, in fact, Dioscorides says "it is kept in vessels of glass, lead, tin or silver; if kept in vessels of any other kind it consumes them and flows away." It was used by them for medicinal purposes. The Romans amalgamated gold with mercury, but whether they took advantage of the principle to recover gold from ores we do not know. Vitruvius makes the following statement: "If quicksilver be placed in a vessel and a stone of a hundred pounds' weight be placed on it, it will swim at the top, and will, notwithstanding its weight, be incapable of pressing the liquid so as to break or separate it. If this be taken out, and only a single scruple of gold be put in, that will not swim, but immediately descend to the bottom. This is a proof that the gravity of a body does not depend on its weight, but on its nature. Quicksilver is used for many purposes; without it, neither silver nor brass can be properly gilt. When gold is embroidered on a garment which is worn out and no longer fit for use, the cloth is burnt over the fire in earthen pots; the ashes are thrown into water and quicksilver added to them; this collects all the particles of gold and unites with them. The water is then poured off and the residuum placed in a cloth, which, when squeezed with the hands, suffers the liquid quicksilver to pass through the pores of the cloth, but retains the gold in a mass within it." Pliny is rather more explicit: "All floats on it (quicksilver) except

gold. This it draws into itself, and on that account is the best means of purifying; for, on being repeatedly agitated in earthern pots it casts out the other things and the impurities. These things being rejected, in order that it may give up the gold, it is squeezed in prepared skins, through which, exuding like perspiration, it leaves the gold pure."

Who's Who in Ancient Metallurgy

HERBERT CLARK HOOVER (1874-), as a mining engineer interested in the history of his profession and its technical processes, undertook with Mrs. Hoover as a recreational activity the translation of *De Re Metallica*, the great treatise on medieval mining and metallurgy. The accomplishment of this project stretched over a period of about five years, and was completed only a short time before World War I involved the translators in world affairs, leading to the White House.

LOU HENRY HOOVER (1875-1944) collaborated with her husband on the translation. Their facility with Latin, familiarity with the technical vocabulary and fine historical sense made the work a great contribution to the record of applied science. As the introduction says: "There are no footnotes in the original text, and Mr. Hoover is responsible for them all."

GEORG BAUER, Latinized to AGRICOLA, (1494-1555) was first a teacher, then a physician. He was town physician, first at Joachimsthal, in the heart of an active mining community, later at Chemnitz, where his many books were written. *De Re Metallica* is the best known of a number of works by Agricola on metals and mining. His other interests are reflected in his Latin grammar, several medical treatises, a political diatribe against the Turks and some theological tracts against the Reformation. His stand on religious controversies of the day caused some embarrassment over where he was to be buried, but during his life he had staunch friends on both sides of the theological fence.

GREEK AND ROMAN authorities quoted in Agricola's text and Hoover's notes are identified below:

AGATHARCIDES (2nd century B.C.) was a Greek geographer whose works are lost. He was quoted by Diodorus Siculus in the 1st century B.C.

DIOSCORIDES (1st centuryA.D.) was a Greek physician who wrote of materia medica and of minerals used medicinally.

GEBER (prior to the 14th century A.D.) is something of a mystery. He is one of the great names to which many books of varying merit have become ascribed. He has been thought to be an Arab alchemist of somewhere between the 7th and 12th centuries, and a Latin scholar of the 13th century who had assimilated much of the Arabic scientific culture. The best of the literature that goes by his name shows familiarity with a large number of chemical processes.

PLINY (23-79A.D.) wrote the "Natural History" which gives some information on precious stones, a little on Roman building stones of his day, and a meagre amount on mining and metallurgy.

STRATO was the author of a lost work

on mines, referred to by Greek authors.

THEOGNIS (6th century B.C.) was a Greek poet.

THEOPHILUS (fl. 1150-1200 A.D.) was a monk who wrote on metal working for ecclesiastical purposes.

THEOPHRASTUS (371-288 B.C.) was assistant to Aristotle, and his successor at the Lyceum. His book "On Stones" is extant, but another "On Metals" has not survived.

VITRUVIUS (1st century B.C.) was a Roman architect. He described pigments made from stones, and wrote a little on contemporary pumps and machinery.

New Flash Heat Treatment for Eggs

➤ EGGS—best replacement for point-scarce meats—may be kept in good edible condition for as much as a year by means of a new flash heat treatment developed by Prof. Alexis L. Romanoff of Cornell University.

The treatment is very simple, and requires only such equipment as may be found in an average kitchen. It consists merely of plunging the eggs in boiling water for five seconds, letting them cool, and putting them away in a refrigerator. Eggs thus treated may even be kept without refrigeration, but they will stay good for only about three months, as contrasted with 12 months in the refrigerator. Cold-storage eggs remain in edible condition for about six months, Prof. Romanoff states.

➤ METHYL METHACRYLATE *can be made to imbed biological specimens much as ancient amber surrounded chance-trapped insects of long ago. The trick to the process lies in careful drying of the specimens before beginning the polymerization process, which requires heat and pressure.*

BOOKS YOU'LL WANT

to enjoy and study

At only 25 cents each, these Science Service books, published in cooperation with the Infantry Journal, are important additions to your reading table. You'll find them ample texts for classes and study groups.

FUNDAMENTALS OF MECHANICS tells the principles and practice of our mechanical world in simple, understandable language, with 145 illustrations, both vivid photographs and clear diagrams. Written by Dr. Morton Mott-Smith and Marjorie Van de Water, Science Service staff writers, it contains 40 ample chapters covering the full scope of the mechanics portion of physics. Based on the official outline of the War Department, it is unusually interesting reading as well as an adequate text. 188 pages. Paper covers, 25c.

FUNDAMENTALS OF ELECTRICITY takes a tough subject and makes it clear, through the writing of Dr. Morton Mott-Smith, with the collaboration of the Science Service staff. The 44 photographs and 41 drawings, the suggested reading and experiments, the questions, all combine with the text to make this course of 40 lessons valuable. It is based on an official outline of the War Department. It takes up magnetism, static electricity, condensers, volts and amperes, storage batteries, electro-magnetism, electric heat and light, induced currents, electric generators, transformers, induction coils, telephones, current rectifiers and other subjects. 125 pages. Paper covers, 25c.

SCIENCE FROM SHIPBOARD is a book of information on the varied life of the sea. Prepared by nineteen scientist-writers and artists, it gives its knowledge simply and directly on such subjects as wind, waves and weather; whales, porpoises and other smaller fish; oceanic birds; time, the calendar and the sun dial; stars, moon, sun and navigation; ships, shore lines and ocean islands. Illustrated with 138 drawings, charts, and graphs. Indexed. 268 pages. $1.50. In paper covers, 25c.

PSYCHOLOGY FOR THE FIGHTING MAN was prepared by a Committee of the National Research Council with the collaboration of Science Service. Over fifty scientists, scientist-writers and Army and Navy psychologists coöperated to write chapters on fear, morale, camouflage, seeing at night, food, sex, rumor, mobs, and panics, to mention a few. It is written for the individual who wants to know his own physical and mental limitations and possibilities. Illustrated with 48 photographs, drawings, charts and graphs. Indexed. 456 pages. Paper covers, 25c. Cloth covers, $1.50.

Order, post paid, from

SCIENCE SERVICE, 1719 N St., N.W., Washington 6, D. C.

The Activities of Science Service

are directed toward presenting science in all its aspects to the people of the world. Through newspapers, radio, magazines, experimental kits and other media, science is interpreted and diffused.

For Individuals:

SCIENCE NEWS LETTER (weekly) summarizes the march of science for scientists and non-scientists alike. This unusual magazine-style *report* brings you the newest information on changes and progress in all fields of science and invention, reporting meetings, summarizing journal articles and reviewing books. $5 a year.

OVERSEAS SCIENCE NEWS LETTER (monthly) takes the latest in science to our fighting men overseas and to scientific good neighbors in foreign lands. Offset printed on thin paper in reduced size, it is sent to U. S. fighters by first class mail for $1.25 per year.

THINGS *of science* (monthly) consists of a box or bulky envelope of science exhibits and experimental materials. These new or unusual, natural or fabricated products are accompanied by complete explanations, suggested experiments and museum-style legend cards for each specimen included in the unit. $4 per year, 50 cents a unit.

CHEMISTRY (monthly) presents the background and current progress of a great and important field of science, in attractive pocket-sized format. Illustrated, with entertaining features that aid the student. The latest of Science Service publications. $2.50 per year.

For Newspapers:

NEWS AND FEATURE SERVICES that provide daily newspapers and other publications with complete, authoritative and interesting coverage of all advances of science. Daily mailings, weekly science page, health column, star maps, etc., are serviced.

For Groups:

SCIENCE CLUBS OF AMERICA, administered by Science Service, brings together and provides material for over 6000 clubs in secondary schools and elsewhere, conducts the annual Science Talent Search, and stimulates study and research by boys and girls as a hobby activity. Affiliation is free.

SCIENCE SERVICE is the endowed, non-profit institution for the popularization of science, incorporated and established in 1921.

Board of Trustees—*Nominated by the American Association for the Advancement of Science:* Edwin G. Conklin, American Philosophical Society; Otis W. Caldwell, Boyce Thompson Institute for Plant Research: Henry B. Ward, University of Illinois. *Nominated by the National Academy of Sciences:* Harlow Shapley, Harvard College Observatory; Warren H. Lewis, Wistar Institute; R. A. Millikan, California Institute of Technology. *Nominated by the National Research Council:* C. G. Abbot, Smithsonian Institution; Hugh S. Taylor, Princeton University; Ross G. Harrison, Yale University. *Nominated by the Journalistic Profession:* A. H. Kirchhofer, Buffalo Evening News; Neil H. Swanson, Executive Editor, Sun Papers; O. W. Riegel, Washington & Lee School of Journalism. *Nominated by the E. W. Scripps Estate:* Max B. Cook, Scripps Howard Newspapers; H. L. Smithton, Executive Agent of E. W. Scripps Trust; Frank R. Ford, Evansville Press.

National Headquarters:
1719 N Street, N.W.
Washington 6, D. C.

➤ **AMERICAN newspapers have played a leading role during the past two decades in informing the world about the progress of science in all fields. SCIENCE SERVICE, the institution for the popularization of science and the world's only science syndicate, has provided the day-by-day reporting and background of scientific advances that have made this possible. Among the newspapers that have joined with Science Service in this important public service are:**

Birmingham (Ala.) *Post*
Alhambra (Calif.) *Post-Advocate*
Berkeley (Calif.) *Gazette*
Culver City (Calif.) *Star-News*
Pasadena (Calif.) *Post*
Redondo (Calif.) *Breeze*
Riverside (Calif.) *Daily Press*
San Francisco (Calif.) *News*
San Pedro (Calif.) *News-Pilot*
Denver (Colo.) *Rocky Mountain News*
Bridgeport (Conn.) *Post*
Hartford (Conn.) *Times*
Waterbury (Conn.) *Sunday Republican*
Washington (D. C.) *Daily News*
Miami (Fla.) *Herald*
Chicago (Ill.) *Times*
Evansville (Ind.) *Press*
Indianapolis (Ind.) *Times*
Council Bluffs (Iowa) *Nonpareil*
Emporia (Kans.) *Gazette*
Covington (Ky.) *Post*
Baltimore (Md.) *Evening Sun*
Boston (Mass.) *Globe*
Springfield (Mass.) *Republican*
Ann Arbor (Mich.) *News*
Bay City (Mich.) *Times*
Detroit (Mich.) *Free-Press*
Flint (Mich.) *Journal*
Grand Rapids (Mich.) *Press*
Jackson (Mich.) *Citizen-Patriot*
Kalamazoo (Mich.) *Gazette*
Lansing (Mich.) *State-Journal*
Muskegon (Mich.) *Chronicle*
Saginaw (Mich.) *News*
Rochester (Minn.) *Post-Bulletin*
Kansas City (Mo.) *Star*
St. Louis (Mo.) *Globe-Democrat*
Camden (N.J.) *Courier-Post*
Newark (N.J.) *Evening News*
Albuquerque (N. Mex.) *Tribune*
Brooklyn (N. Y.) *Eagle*
Buffalo (N. Y.) *Evening News*
New York (N. Y.) *Times*
New York (N. Y.) *World-Telegram*
Niagara Falls (N. Y.) *Gazette*
Rochester (N. Y.) *Times-Union*
Rome (N. Y.) *Sentinel*
Syracuse (N. Y.) *Post-Standard*
Troy (N. Y.) *Observer-Budget*
Utica (N. Y.) *Observer-Dispatch*
Akron (Ohio) *Beacon-Journal*
Cincinnati (Ohio) *Post*
Cleveland (Ohio) *Press*
Columbus (Ohio) *Citizen*
Dayton (Ohio) *News*
Toledo (Ohio) *Blade*
Oklahoma City (Okla.) *Oklahoman & Times*
Philadelphia (Pa.) *Record*
Pittsburgh (Pa.) *Press*
York (Pa.) *Gazette & Daily*
Wilkes-Barre (Pa.) *Sunday Independent*
Providence (R. I.) *Sunday Journal*
Anderson (S. C.) *Independent*
Chattanooga (Tenn.) *Times*
Knoxville (Tenn.) *News-Sentinel*
Memphis (Tenn.) *Press-Scimitar*
El Paso (Tex.) *Herald-Post*
Fort Worth (Tex.) *Press*
Houston (Tex.) *Press*
Lynchburg (Va.) *Daily Advance*
Norfolk (Va.) *Ledger-Dispatch*
Roanoke (Va.) *World News*
Winchester (Va.) *Star*
Toronto (Ont.) *Evening Telegram*
Victoria (B. C.) *Times*

★ ★ ★

SCIENCE SERVICE